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BULLETIN A 48

Geology and Mineral Resources of the Donegal Quadrangle, Pennsylvania

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GEOLOGY AND MINERAL RESOURCES OF THE DONEGAL QUADRANGLE, PENNSYLVANIA

By Marchant N. Shaffner

INTRODUCTION

This report is part of a detailed geologic mapping program which has been conducted by the Fourth Pennsylvania Geologic Survey in the important bituminous coal-producing regions of the State since 1919.

Geologic field mapping for this report began in 1952 and continued throughout parts of each summer until 1960.

LOCATION

The Donegal quadrangle is in southwestern Pennsylvania, and covers an area of approximately 228 square miles. It extends between north latitude 40° 00′ to 40° 15′ and between west longitude 70° 15′ to 79° 30′. The southeastern part of Westmoreland County occupies the northern and east-central portions of the quadrangle whereas the southwestern and southeastern sections of the quadrangles are included within portions of Fayette and Somerset Counties respectively.

PREVIOUS WORK

The first reference to the geology in the Donegal area was by H. D. Rogers (1858) who furnished some brief descriptions. The area was later mapped in greater detail by J. J. Stevenson (1877, 1878) with the Second Pennsylvania Geologic Survey. The general geologic interpretations presented in these early reports are remarkably accurate in spite of the poor topographic control available at that time.

The geology in the southern part of the Donegal quadrangle lying within Fayette County is included in a relatively recent report by Hickok and Moyer (1940). Revision of the geology in this part of the quadrangle was warranted by aquisition of additional geologic information with which some of the generalities in the former mapping were improved.

PHYSIOGRAPHY

The Donegal Quadrangle lies entirely within the Appalachian Plateau Province (Fenneman, 1938) and is characterized by a northeast-southwest trending series of gently folded structures. The structures correspond with the main topographic features, for the anticlines form the higher altitudes whereas the synclines form the valleys.

The total relief in the Donegal quadrangle exceeds 1750 feet. Laurel Hill and Chestnut Ridge form the prominent ridges which exceed altitudes of 2900 feet and 2300 feet respectively. They are underlain by the Pocono Group and Mauch Chunk Formation of Mississippian

Age, and the Pottsville and Allegheny Groups of Pennsylvanian Age. By comparison the Ligonier and Latrobe Valleys are underlain by the younger formations of Pennsylvanian Age—the Conemaugh and Monongahela. The lowest altitude (1120-1140 feet) occurs in the Ligonier Valley in the northeast part of the quadrangle where Fourmile Run leaves the area.

The stream pattern is predominantly dendritic with consequent streams draining southeast or northwest off the slopes of the higher hills. By comparison, the direction of drainage in the valleys is either northeast or southwest or parallel to the regional structural trend.

A spectacular drainage phenomenon in the quadrangle is evident northwest of Donegal where Jacobs Creek has cut a deeply entrenched channel through a zone of presumable structural weakness in Chestnut Ridge and, at the same time, has migrated headward to capture some of the drainage from the east side of the ridge.

CULTURE

Approximately 40 percent of the Donegal quadrangle is forested upland and 60 percent is cleared areas in the valleys most of which is cultivated; agriculture is presently the chief industry. The population is sparse and the centers of population are small rural villages and typical company-owned mining towns.

Large-scale coal mining flourished in the Latrobe and Ligonier Valleys from the latter part of the 19th century to the early part of the 20th century. Only one large deep mine was active when this survey was made.

The area is served by rail transportation with a spur of the Pennsylvania Railroad traversing the Latrobe Valley and a spur of the Baltimore and Ohio Railroad that traverses the Ligonier Valley from the south and terminates at Roaring Run. The area is everywhere accessible by a network of improved roads. The Pennsylvania Turnpike crosses the central part and connects with Pa. Routes 31 and 711 at Donegal.

STRUCTURE

FOLDING

The geologic structure of the Donegal quadrangle is shown by 50-foot contour intervals and a cross-section on Plate 1 accompanying this report. The horizon of the Upper Freeport coal bed is the datum for structure. It was selected as the logical datum unit because it not only is a formational boundary and has an extensive linear outcrop, but also because it occupies an approximately medial position in the thick stratigraphic column of the exposed strata in the quadrangle.

The major structures of the area are broad, gently dipping, nearly symmetrical folds which trend in a general N. 30° E. direction. The axis of the folds is irregularly linear and mildly plunging. The limbs of the folds dip from less than 100 feet per mile to about 1000 feet per mile with the steeper dips occurring in the western limbs of the anticlines. Steeper stream gradients correlate with the steeper dips and have resulted in a general eastward shift of the topographic highs away from the anticlinal axes. Structural relief, as measured on the Upper Freeport horizon, ranges from about 900 to 2100 feet.

Four major structures occur in the quadrangle; from southeast to northwest they are: The Laurel Hill anticline, the Ligonier syncline, the Chestnut Ridge anticline and the Latrobe syncline.

Laurel Hill anticline. The Laurel Hill anticline is one of the most prominent structures in western Pennsylvania. It extends from northern West Virginia, where it is called Briery Mountain anticline, northeastward across Pennsylvania for a distance of approximately 170 miles into northwestern Lycoming County where it is known as the Hyner anticline.

The Laurel Hill anticline extends about 8 miles along strike across the southeast corner of the Donegal quadrangle. In this area it appears as an elongated dome with a structural closure of about 250 feet. The highest point of the dome is near Kooser fire tower. The east limb dips about 300 feet per mile; the steeper west limb dips about 600 feet per mile.

Ligonier syncline. The Ligonier syncline begins in southeastern Fayette County and extends northeastward into southwestern Clearfield County where it is called the Barnesboro syncline. It enters the Donegal quadrangle as a structural low near Saltlick in the southeastern corner of the map (Plate 1). The trace of its axis crosses and recrosses Indian Creek in a northeastward direction to a point about 1¼ miles north of Jones Mills where it loses its identity in a mild structural low. It reappears northwest of Donegal as a northeast plunging structural bulge originating in the foothills of Chestnut Ridge. As it continues northeastward, it gradually widens into a broad, nearly symmetrical basin. The axis plunges northeastward at the average rate of about 70 feet per mile to where it leaves the northeast corner of the quadrangle.

The east limb of the syncline rises rather abruptly to become the steep western limb of Laurel Hill anticline. The west limb rises more gradually and becomes increasingly steeper toward the Chestnut Ridge anticline.

Chestnut Ridge anticline. The Chestnut Ridge anticline is the most extensive structure in western Pennsylvania. It has been traced from West Virginia northeastward across Pennsylvania to the New York State line in Bradford County where it is called the Wellsboro anticline.

The Chestnut Ridge anticline trends northeastward across the western part of the Donegal quadrangle. It is featured by two elongated, narrow-crested domes which rise northeastward and southwestward respectively from a saddle centering near Jacobs Creek. The south dome has a structural closure of about 400 feet with its high point west of Clinton along the western boundary of the quadrangle. The north dome extends for a distance of 7½ miles from Jacobs Creek northeastward to the north-central boundary of the quadrangle. This dome has a closure of over 200 feet with the highest point centered near St. Boniface Chapel. The axes of both elongated domes trend northeastward and are generally coincident with topographic highs. The average dip of the west limb is about 500 feet per mile; the dip on the east is about 400 feet per mile.

Latrobe syncline. The Latrobe syncline occupies the northwestern corner of the Donegal quadrangle. Its southwest mildly plunging axis extends 4.3 miles across the corner of the quadrangle. This syncline begins in northern West Virginia, trends northeastward across Fayette County, where it is called the Uniontown syncline, and continues northeastward across Westmoreland County into southern Indiana County.

FAULTING

Normal faults with displacements of a few inches were noted in exposures in some of the coal strip mines. Faulting of probable great magnitude is indicated by topographical and structural anomalies. Subsurface faulting at depths of about 8000 feet is disclosed in some of the wells drilled for natural gas, and it was reported by reliable authority that systematic seismograph exploration on Laurel Hill and Chestnut Ridge has revealed that the subsurface structure is greatly complicated by multiple faulting.

The most pronounced surface indication of faulting is on Chestnut Ridge west of Rodney and Acme where the axis of the anticline has rather strong flexures which generally coincide with the irregular trend of the crest of the Ridge. Additional supporting indication of faulting in that locality is the presence of a structural bulge, and a mild local reversal of the dip on the east limb of the anticline in the vicinity of the Pennsylvania Turnpike. A somewhat similar structural condition exists on Laurel Hill anticline in the southeastern part of the quadrangle, where a relatively milder flexure of the anticline axis is accompanied by a structural bulge on the east limb of the anticline west of Center Church.

The structural anomalies as represented in the flexures of the axes of Laurel Hill anticline, Ligonier syncline, and Chestnut Ridge anticline are remarkably coincident with a line bearing north 45° west. Similar structural conditions exist elsewhere in the Appalachian Plateau Province of western Pennsylvania; the mechanics that caused them are speculative, but they appear to be cross-faults which probably occur at considerable depth. Evidence for subsurface faulting is given in the ensuing discussion.

Drilling for natural gas on the elongated dome of Chestnut Ridge anticline north of Jacobs Creek (known as the Lycippus field) has disclosed strike faults in the subsurface strata having considerable displacement. Figure 13 shows the deep wells drilled for gas in the Lycippus field with the respective depths to the top of the Onondaga Limestone. The names of the wells and other pertinent data are given in Table 6.

Five gas wells (Ba 6, 7, 9, 11, 37) in the Piper pool located in the north-central part of the quadrangle, encountered the top of the Onondaga at depths ranging from 5880 to 6155 feet below sea level or at an average depth of 6000 feet below sea level. The "out-step" well to the east (Ba 10) encountered the top of the Onondaga at 6461 feet below sea level, or an apparent down-throw of about 400 feet. The coincidental topographical and structural offset to the east at the north-central boundary of the quadrangle may reflect subsurfaces faulting.

Southwest of the Piper pool, nine wells (Ba 20, 21, 33, 27, 30, Aa 39, 40, Ab 7, 10) in the St. Boniface Chapel pool, drilled in a general northeast alignment, encountered the top of the Onondaga Limestone at depths ranging from 5331 to 5615 feet below sea level. The two "out-step" wells to the east (Ba 28, Ab 11) encountered the top of the Onondaga Limestone at depths of 6296 and 6077 feet below sea level respectively. The differences in depth to the top of the Onondaga Limestone between the "out-step" wells and those farther west indicate a fault striking generally northeast with an average downthrow of 630 feet on the east side.

JOINTS

Jointing is common in sedimentary rocks, but it is a specialized subject that merits only summarized recognition in this report. For extensive studies on joints, the reader is referred to the work of John M. Parker, III (1942), and Nickelson and Hough (1958).

Irregularly spaced joints oriented in two systems at approximate right angles to each other were noted in the quadrangle. The dip joints, at right angles to the trend of the major structures are best developed and have relatively smooth surfaces; the strike joints, or those parallel to the major structures show poor development and exhibit rough surfaces. Dip joints are generally believed to have been caused by the mechanics of compressional forces, whereas the strike joints have been caused by tensional forces. Joints may extend to the full thickness of homogeneous rocks. This is exemplified in thick, massive blocks of sandstones that have broken away from cliffs and gradually slide down hill from the outcrop.

Excellent examples of jointing are afforded in the irregularily-spaced face and butt cleats of coal beds. The face cleats correspond to the dip joints. They are exceedingly well developed and have very smooth, bright surfaces. The butt cleats which correspond to the strike joints are similarly poorly developed or obscure. The spacing of the cleats range from a small fraction of an inch up to rarely over 12 inches apart.

SHEARING

Shearing or cleavage, an uncommon physical feature of bituminous coals, was noted in one locality in the quadrangle. In a strip mine southeast of St. Boniface Chapel (Ba 24), the upper part of the Brookville coal contains a sheared layer 5 inches thick. The planes of shearing are irregularly spaced and all of them are less than one inch apart. They dip northwest parallel to the trend of folding, and they form an angle of about 50 degrees with the normal bedding planes of the coal bed.

UNCONFORMITIES

The major unconformity of the Pennsylvania-Mississippian contact is well known. It was recognized in the New Florence quadrangle at the northeast (Shaffner, 1958). In the Donegal quadrangle it is well exposed along the north side of the Turnpike in the east limb of Chestnut Ridge anticline, where the base of the lower Connoquenessing sandstone lies irregularly on the eroded surface of Mauch Chunk shale.

Local unconformities are common in the Conemaugh and Allegheny Formations, particularly at the base of sandstones. Many are exposed in some of the highwalls of coal strip-mines, where sandstone may lie on an eroded surface of roof shale, or fill a channel cut through a coal bed. These sandstone-filled channels are called "faults" by the miners.

STRATIGRAPHY

SUBSURFACE ROCKS

The subsurface rocks in the Allegheny Plateau province of Pennsylvania are well known from studies of deep wells which have been drilled for natural gas in the Oriskany Sandstone and Onondaga Limestone of lower Devonian Age. Logs of two deep wells drilled in the Donegal quadrangle are shown on pages 8 to 22. The Fred Musnug no. 2 well (Ba 10) was drilled by the Peoples Natural Gas Company on Chestnut Ridge. The A. A. Dupre no. 1 well was drilled on the Laurel Hill anticline by the Mid-Atlantic Oil and Gas Company. The detailed lithologic descriptions in these logs were made by company geologists. The terminology, correlations, and subdivisions are those of the authors. The ensuing descriptions are based largely on these sample-study logs and logs of the well drillers.

DEVONIAN SYSTEM

Wells drilled for natural gas in the quadrangle have reached depths exceeding 9000 feet, and have penetrated unexposed rocks from the lower Mississippian to the lower Devonian. The average thickness of the Devonian penetrated in the two wells is about 7500 feet but this figure may be questionable because of the possible faulting at depth.

Lower Devonian

Rocks of lower Devonian Age include the basal Helderberg Formation and the overlying Oriskany Formation. The Helderberg is a gray to black limestone. It was penetrated 150 feet but the total thickness is not known. The Oriskany Formation is composed of white to gray sandstone, ranging in thickness from 20 to 100 feet.

Middle Devonian

The Middle Devonian or Hamilton Group of central Pennsylvania, extends from the top of the Oriskany Sandstone to the base of the Tully Limestone, and is about 600 feet thick. The Onondaga Formation occurs at its base and is composed of limestone and chert about 150 feet thick. The section above the Onondaga Limestone to the base of the Tully Limestone is composed of gray, dark gray to black shales with subordinate limy beds. The black shale overlying the Onondaga correlates with the Marcellus of central Pennsylvania.

Upper Devonian

The upper Devonian rocks include the units from the base of the Tully Limestone to the Oswayo Formation. The total average thickness of the sequence is about 6200 feet.

The Tully limestone is dark gray and is from 70 to 90 feet thick.

Because of its wide distribution in central and western Pennsylvania, it is an important stratigraphic marker for deep well drillers.

About 700 feet of dark shales with minor amounts of siltstone occur above the Tully Limestone. The lithologies change to a succession of shale, siltstones, and sandstone from this section of the stratigraphic column up to the base of the Catskill red beds.

The section from the Tully to the Catskill contains the "Chemung" and "Portage" beds of central Pennsylvania, and the "shallow" gas sands of western Pennsylvania.

The Catskill Formation is predominantly red shales and siltstones with interbedded greenish siltstones or shales and white to greenish-gray sandstones. The maximum recorded thickness on Chestnut Ridge is 380 feet. On Laurel Hill the Catskill is about 470 feet thick. The Catskill is, in part, equivalent to the Cattaraugus of northwestern Pennsylvania which contains the Venango oil sands.

The top of the Devonian system in the sample log of the Musnug no. 2 well on Chestnut Ridge is placed at the top of a dominantly silty section 160 feet above the Catskill red beds. This unit corresponds in position and lithology to what Bayles has described as Oswayo beds from his sample study of the Camilla Griffin no. 3 well on Chestnut Ridge in the New Florence quadrangle where its thickness is 221 feet (Shaffner, 1958). In the sample log of the Dupre no. 1 well on Laurel Hill, the section composed of siltstone, shale, limestone, and sandstone, extending 240 feet above the top of the Catskill, is the probable equivalent of the Oswayo Formation.

Sample log of Fred Musnug no. 2 well (Ba 10)
Peoples Natural Gas Company
Sample study by P. W. Garrett, Jr. and P. G. Freund

Top	*Bottom*	*Description*
220′		PENNSYLVANIAN SYSTEM
220′		POTTSVILLE SERIES
0	30	Cellar, No samples
30	40	Shale; 90%, silty, medium-gray. Siltstone: 10%, fine-grained, medium gray. Traces of white, fine-grained sandstone
40–90		*Homewood (1st Salt) Sandstone*
40	50	Sandstone: 20%, white, fine-grained, non-calcareous. Shale; 80%; 50% white, slightly silty; 30% brownish
50	60	Shale: 60%, as above. Siltstone: 10%, medium-gray. Sandstone: 30%, white, fine-grained, non-calcareous. Traces of coal
60	70	Sandstone: 70%, white, fine to very fine-grained. Siltstone: 10%, grayish-white, fine-grained. Shale: 20%, grayish-white, traces of black
70	90	Sandstone: 100%, white, medium to fine-grained, slightly calcareous

Top	*Bottom*	*Description*
90	100	Siltstone: 90%, light-gray, coarse-grained, sandy. Sandstone: 10%, white as above
100	110	Siltstone: 70%, as above. Sandstone: 30%, white, medium-grained, brownish material between some of the grains
110	120	Siltstone: 100%, light gray and a little dark gray, coarse-grained, some a little sandy. Traces of coal
120	130	Sandstone: 60%, white, fine to medium-grained. Siltstone: 30% light to medium-gray. Shale: 10% black. Siderite nodules present
130	140	Siltstone: 90% light to medium-gray. Shale: light-gray to brown. Pyritic
140	150	Sandstone: 40%, tannish-white, fine-grained. Siltstone: 40% medium-gray. Shale: 20%, silty, medium to dark-gray
150	160	Shale: 80%, dark-gray, very hard, silty. Siltstone: 10% as above. Chert: 10%, light tan
160	170	Shale: 60%, medium-gray, slightly silty. Siltstone: 30% light-gray, medium-grained. Sandstone: 10%, medium to fine-grained, white
170	220	*Connoquenessing (2nd Salt) Sandstone*
170	200	Sandstone: 50%, white to light-gray, mostly fine-grained with some medium, clear, rounded grains. Siltstone: 40%, dark gray. Shale: 10%, dark-gray, silty
200	210	Sandstone: 100%, white, medium to fine-grained, Sideritic balls present
210	220	Sandstone: 90%, as above, very sideritic. Shale: 10%, red, slightly silty
970′		MISSISSIPPIAN SYSTEM
190′		MAUCH CHUNK SERIES
220	230	Sandstone: 50% as above. Shale: 50%, red, green, gray
230	250	Siltstone: 100%, green, very fine-grained
250	260	Siltstone: 50%, green, very fine-grained, traces of biotite and glauconite, calcareous. Siltstone: 50%, red, shaly, fine-grained
260	270	Shale: 50% red, 50% green, slightly silty
270	290	Shale: 25% red, shaly, 75% red, silty
290	310	Shale: 75% red, 25% grayish-green, both silty
310	340	Shale: 100% red, silty
340	400	*Greenbrier Limestone*
340	350	Limestone: 100%, light-gray
350	360	Shale: 75%, light-gray, silty. Limestone: 25%, light gray
360	370	Shale: 90% red, silty; 10% green. Traces of gray shale and limestone
370	380	Shale: 90% light-gray, silty; 10% red
380	390	Shale: 70%; 50% red, silty; 20% gray, slightly calcareous. Sandstone: 30%; 25% white, medium to fine-grained, carcareous; 5% light-green, fine-grained. Traces of gray limestone
390	400	Limestone: 95%; 60% red, sandy to pebbly. oolitic; 35% grayish-white, sandy, oolitic. Traces of brown and gray shale, white sandstone
400	410	Shale: 100%; 70% red, some a little sandy; 30% green with scattered sand grains
90′		LOYALHANNA SERIES
410	500	*Loyalhanna Limestone*
410	440	Sandstone: 100%, white, medium-grained, very calcareous. 420–30 some pale-green. 430– 40 a few coarse, clear grains
440	460	Limestone: Whitish-gray, sandy, some coarse, clear grains
460	470	Limestone: Grayish-white, sandy, silty, a few coarse frosted grains
470	480	Limestone: as above with many coarse, clear grains
480	500	Sandstone: Grayish-white to greenish-gray, medium to fine-grained, calcareous

Top	*Bottom*	*Description*
690′		POCONO SERIES
500	680	*Big Injun Sandstone*
500	510	Sandstone: 50% as above. Siltstone: 25% light-gray. Shale: 25% light gray
510	520	Sandstone: 75% as above. Siltstone: 25%
520	550	Sandstone: Grayish-white, mostly fine-grained, with some medium and coarse grains, slightly calcareous. Some of the grains are coarse, well rounded and frosted
550	570	Sandstone: Light-gray, fine-grained, with a few medium grains, traces of glauconite, carbonaceous inclusions, very slightly calcareous
570	580	Siltstone: 75%, medium to dark-gray, very dense, fine-grained. Sandstone: 25% as above
580	600	No sample—No returns from air drilling—now using mud
600	670	Sandstone: 100%, white to light-brown and gray, fine to medium-grained, calcareous. Traces of gray, silty shale, black shale and red shale. Traces of pyrite at 640
670	680	Sandstone: 95%, light-green to light-brownish-white, fine-grained, slightly calcareous. Siltstone: 5%, light-gray and brown, shaly
680	790	*Patton Sandstone*
680	690	Siltstone: 85%, light to medium-gray, fine-grained. Sandstone: 10%, as above. Shale: 5%, light-gray, silty
690	700	Siltstone: 60%, as above. Sandstone: 40%, as above. Traces of pyrite
700	720	Sandstone: 90%, grayish-white, fine-grained, very slightly calcareous. Siltstone: 10%, light gray. 710– 20 light gray glauconitic
720	740	Siltstone: 60%, light-gray, 10% green, shaly. Sandstone: 40% as above
740	760	Sandstone: 90%, white, fine-grained. Siltstone: 10%, gray. Traces of red siltstone
760	790	Siltstone: 90%, gray, very fine-grained. Sandstone: 10%, as above. Traces of brown siltstone
790	800	Shale: 70%, light-brownish-gray. Siltstone: 10%, gray. Sandstone: 20%, white, fine to medium-grained
800	940	*Squaw Sandstone*
800	890	Sandstone: 100%, white with a brownish cast, fine-grained, slightly calcareous. Traces of red and gray silty shale, and slickenside plates. 830– 90—20% gray siltstone
890	920	Sandstone: 90%, white to light-gray, fine-grained, very calcareous. Siltstone: 10%, light-gray. Formation is very hard for it is badly iron stained. Sandstone has many dark inclusions
920	940	Sandstone: 80%, whitish with gray and green casts, conglomeratic (mostly fine-grained with 1– 2 MM frosted grains, very calcareous. Siltstone: 10% light gray. Shale: 10%, light gray
940	970	Siltstone: 70%, medium-gray, medium-grained. Sandstone: 30% as above. Traces of shale. Some of the siltstone has a brownish cast
970	980	No sample
980	990	Cement
990	1010	Siltstone: 75%, medium-gray, very fine-grained. Cement: 25%
1010	1020	*2nd Gas Sandstone*
1010	1020	Sandstone: White, medium to fine-grained. Siltstone: light-blue-gray. Cement
1020	1030	Siltstone: 80%, gray. Cement: 20%
1030	1040	Sandstone: 50%, tannish, fine-grained. Siltstone: 25% as above. Cement 25%
1040	1060	Siltstone: 80% as above. Cement: 20%
1060	1080	Siltstone: 50% as above. Sandstone: 40%, grayish-white, fine-grained. Cement: 10%

Top	*Bottom*	*Description*
1080	1090	Siltstone: 75%, medium to dark-gray, medium-gray. Sandstone: 20%, grayish-white, fine-grained. Cement: 5%
1090	1100	Sandstone: 80%, white, medium to fine-grained. Siltstone: 20% as above
1100	1110	Siltstone: 60%, medium-gray, medium to fine-grained. Sandstone: 30% as above. Shale: 10% gray
1110	1190	*Murrysville Sandstone*
1110	1130	Sandstone: 50%, grayish-white and some green shale, fine-grained with a few coarse-grains. Siltstone: 40% as above. Shale: 10% gray
1130	1160	Sandstone: 90%, white, fine-grained. Siltstone: 10% as above. Non-calcareous
1160	1170	Sandstone: 70%, grayish-green, fine to very fine-grained. Siltstone: 30%, gray, fine-grained
1170	1180	Sandstone: 90% as above. Siltstone: 10% as above
1180	1190	Sandstone: 70%, grayish-green, fine to very fine-grained, a few coarse grains. Siltstone: 30% as above
7583′		DEVONIAN SYSTEM
6750		*Upper Devonian Series*
1190	1210	Siltstone: 70%, light-gray, medium-grained. Sandstone: 20% as above. Shale: 10% gray. At 1200—10% clay
1210	1300	*Hundred Foot Sandstone*
1210	1220	Sandstone: 80%, white to light-gray, fine-grained with numerous 1– 2 MM grains, mostly milky and sub-rounded. Siltstone: 20%, gray
1220	1240	Sandstone: 80%, as above, except all fine-grained. Siltstone: 20%, gray
1240	1270	Siltstone: 90%, greenish-gray, medium-grained. Sandstone: 10%, greenish-gray
1270	1300	Sandstone: 90%, greenish-gray and some white, fine to very fine-grained. Siltstone: 10%, gray
1300	1330	Siltstone: 80%, light-greenish-gray to gray, coarse-grained. Sandstone: 20%, white, fine-grained. Traces of tannish silty shale
1330	1350	*Thirty Foot Sandstone*
1330	1340	Siltstone: 60%, light-gray, fine-grained. Sandstone: 40%, white to light-gray, fine-grained
1340	1350	Sandstone: 50%, light-gray, very fine-grained. Siltstone: 40%, light-gray and 5% red, 10% green, medium to very fine-grained. Shale: 10%, gray
1350′		*Top of Devonian Red Rock*
1350	1360	Siltstone: 100%, red, very fine-grained, shaly
1360	1370	Siltstone: 100%; 50% red, 30% green, 20% gray; all very fine-grained and shaly
1370	1380	Siltstone: 100%; 80% gray, 10% green, 10% red; very fine-grained
1380	1420	*Snee Sandstone*
1380	1390	Sandstone: 70%, pale-greenish-gray, very fine-grained. Siltstone: 30%; 10% red, 20% gray, fine-grained
1390	1410	Sandstone: 70% as above. Siltstone: 30%; 20% red, 10% gray, both fine-grained
1410	1420	Sandstone: 50%, very fine-grained, white. Siltstone: 50%; 40% red, very fine-grained; 10% gray
1420	1430	Siltstone: 90%; 40% red, 50% gray. Sandstone: 10%, light gray
1430	1440	Siltstone: 90%; 60% red, 30% gray. Sandstone: 10%
1440	1450	Siltstone: 90%; 50% grayish-green, 40% red. Sandstone: 10%
1450	1460	Siltstone: 95%; 85% red, very fine-grained; 10% greenish-gray. Sandstone: 5%
1460	1470	Siltstone: 90%; 60% red, 30% green. Sandstone: 10%

Top	*Bottom*	*Description*
1470	1490	*Gordon Stray Sandstone*
1470	1490	Sandstone: 80%, greenish-gray, very fine-grained. Siltstone: 10% red, 10% gray
1490	1510	Siltstone: 95% red. Sandstone: 5%. Micaceous
1510	1520	*Gordon Sandstone*
1510	1520	Sandstone: 80%, white, fine-grained. Siltstone: 20% red and micaceous
1520	1530	Sandstone: 90% as above. Siltstone: 10% red and green
1530	1560	Siltstone: 90%, red, a little green. Sandstone: 10% very fine-grained, white
1560	1570	Siltstone: 95%; 60% red, 35% green and gray. Sandstone: 5%
1570	1580	Siltstone: 95%: 85% red, 10% green. Sandstone: 5%
1580	1590	Siltstone: 95%; 60% red, 35% green and gray. Sandstone: 5%. Micaceous
1590	1610	*Fifth Sandstone*
1590	1600	Sandstone: 95%, pale-green-white, very fine-grained. Siltstone: 5%
1600	1610	Siltstone: 80%; 40% red, 40% green and gray. Sandstone: 20%
1610	1620	Siltstone: 95%; 60% greenish-white, 35% red. Sandstone: 5%
1620	1670	Siltstone: 95%; 80% red, 15% greenish. Sandstone: 5%
1670	1690	Sandstone: 70%, grayish-white, very fine-grained. Siltstone: 30%, gray, shaly
1690	1700	Siltstone: 80%; 30% red, 50% greenish. Sandstone: 20%, white
1700	1710	Siltstone: 100%; 95% red, 5% greenish
1710	1730	Siltstone: 90%; 50% red, 40% green. Sandstone: 10%
1730	1740	Siltstone: 100%; 85% red, 15% green and sandy
1740	1820	*Bayard Sandstone*
1740	1750	Sandstone: 60%, white, fine-grained. Siltstone; 40% red
1750	1760	Siltstone: 50%, gray. Sandstone: 30%, greenish-white, fine-grained. Shale: 20% gray, silty
1760	1780	Sandstone: 95%, white, medium to fine-grained. Siltstone: 5%, red
1780	1800	Sandstone: 60%, as above. Siltstone: 40%, mostly red, some pale-green
1800	1820	Sandstone: 50%, grayish-white, fine-grained. Siltstone: 50%; 40% light-greenish-gray coarse to fine-grained; 10% red. A few medium-size sand grains
1820	1860	Siltstone: 90%, greenish-gray with a little white, coarse-grained. Sandstone: 10%, white fine-grained. (Maybe a sandy siltstone.) Traces of red siltstone, cavings
1860	1910	*Bayard Stray Sandstone*
1860	1880	Sandstone: 80%, grayish-white, mostly fine-grained, with numerous medium-size grains. Siltstone: 20%, as above. Some grains are rounded and clear
1880	1890	Sandstone: 100%, fine to very fine-grained. Pinkish-white
1890	1900	Sandstone: 70%, as above. Siltstone: 30%, gray, shaly
1900	1910	Sandstone: 50% as above. Siltstone: 30%, gray. Shale: 20%, gray, silty
1910	1940	Shale: 60%, gray, silty. Siltstone: 30%, light gray. Sandstone: 20%, grayish-white, fine-grained
1940	1980	Siltstone: 70%, medium-greenish-gray, coarse to medium-grained. Shale: 20%, gray, silty. Sandstone: 10%, very fine-grained, greenish-white
1980	2000	Shale: 90%; 70% gray, 20% white, slightly silty. Siltstone: 10%, greenish-white, very fine-grained
2000	2070	Siltstone: 80%, medium-greenish-gray, coarse-grained. Shale: 20%, gray, silty. Traces of a whitish-purple fine sandstone. 2020—sandy—5%. At 2050 several coarse sand grains
2070	2080	Shale: 90%; 70% gray, 20% white, slightly silty. Siltstone: 10%, grayish-white, coarse

Top	*Bottom*	*Description*
2080	2200	Siltstone: 80%, medium-greenish-gray, coarse-grained. Shale: 20%, gray, silty. Traces of a whitish-purple, fine-grained sand and coarse white sand grains. At 2130– 50—10% fine sand. At 2180—20% shale
2200	2210	Siltstone: 90%, light-greenish-gray, medium to fine-grained. Shale: 10%, white to gray
2210	2230	Siltstone: 80%, medium-greenish-gray, coarse to fine-grained. Shale: 10% gray. Sandstone: 10%, white, fine-grained with a few medium grains
2230	2260	Shale: 70%, light-greenish-gray, silty. Siltstone: 30%, light-greenish-gray, coarse to fine-grained
2260	2310	Shale: 60% as above. Siltstone: 30% as above. Sandstone: 10%, light-greenish-white, fine-grained, with a few medium grains
2310	2320	Sandstone: 90%, brownish-white, medium to very fine-grained. Siltstone: 10%
2320	2350	Shale: 60%, light-gray, slightly silty. Siltstone: 40% coarse-grained, light-gray. At 2330 one coarse sand grain
2350	2360	Sandstone: 60%, light-gray, fine-grained, with numerous medium and a few coarse grains. Siltstone: 40%, coarse-grained, light-gray
2360	2370	Siltstone: 80% as above. Shale: 20% as above
2370	2410	Shale: 80% as above. Siltstone: 20% as above. Scattered sand grains
2410	2430	*Speechley Stray Sandstone*
2410	2420	Sandstone: 90%, white, fine-grained. Siltstone: 10%
2420	2430	Shale: 80%, gray, silty. Sandstone: 20%, as above, with many medium grains
2430	2460	Shale: 60%, gray, silty. Siltstone: 30%, gray, coarse-grained. Sandstone: 10% as above, only a few medium grains
2460	2520	Siltstone: 70%, light-gray with greenish cast, medium-grained. Shale: 30% as above. Traces of sandstone. At 2510—5% red siltstone and 1—2% sand
2520	2530	Siltstone: 70%; 50% greenish-gray, medium-grained; 20% red, medium-grained, sandy. Shale: 20% gray. Sandstone: 10%, grayish-white, fine-grained with a few medium grains
2530	2540	Shale: 50%, greenish-gray, silty. Siltstone: 40% greenish-gray. Sandstone: 10%; 5% as above; 5% purplish, salt and pepper, very fine-grained
2540	2550	Shale: 80% as above. Siltstone: 20%, greenish-gray, coarse to medium-grained
2550	2570	Shale: 60%, as above. Siltstone: 20% as above. Sandstone: 20%, grayish-white, fine-grained, with a few medium grains
2570	2590	*Speechley Sandstone*
2570	2580	Sandstone: 80%, white, fine to medium-grained, with a few well rounded, clear, medium grains. Shale: 20%, silty
2580	2590	Sandstone: 80% as above. Siltstone: 20%, red, green, and gray
2590	2600	Shale: 90%, light-greenish-gray, silty. Sandstone: 10% mostly very fine-grained, a few medium grains
2600	2680	*Tiona Sandstone*
2600	2620	Sandstone: 60%, grayish-white, very fine to medium-grained. Siltstone: 30%, gray, coarse to fine. Shale: 10%, gray
2620	2640	Shale: 50%, light-gray. Siltstone: 50%, grayish-white, fine-grained
2640	2650	Sandstone: 50%, grayish-white, fine-grained. Siltstone: 30% coarse to fine-grained. Shale: 20% light-gray
2650	2670	Sandstone: 90%, grayish-white, very fine-grained, with some coarser grains up to medium size. Siltstone: 10%, light-gray. (Traces of pale-blue sand)
2670	2680	Siltstone: 50%, light-gray and some brownish salt and pepper (sandy). Shale: 20%, gray. Sandstone: 30%, light-gray, fine-grained with a few medium grains

Top	*Bottom*	*Description*
2680	2690	Siltstone: 80%, light-brown, salt and pepper texture. Sandstone: 10% as above. Shale: 10% as above
2690	2720	Shale: 70%, light-gray, silty. Siltstone: 30%, sandy
2720	2730	*First Balltown Sandstone*
2720	2730	Sandstone: 70%, brownish-white, very fine-grained, silty. Siltstone: brownish to gray, coarse to fine-grained. A few medium sand grains
2730	2760	Shale: 70%, gray, silty. Siltstone: 30%, light-gray, mostly fine-grained
2760	2770	Siltstone: 50%, light-gray and dark-gray, salt and pepper texture, light gray is fine-grained, salt and pepper is coarse-grained, sandy. Shale: 30%, light-gray, silty. Sandstone: 20%, light-grayish-white, mostly very fine-grained, a few medium grains
2770	2800	Shale: 70%, light-gray, silty. Siltstone: 30%, light-gray, coarse to very fine-grained, a little sand
2800	3080	Not studied
3080	3090	Siltstone: 90%, light-greenish-gray, fine to coarse-grained. Sandstone: 10%, light-greenish-gray, very fine-grained
3090	3100	Siltstone: 50% as above—Sandstone: 50% as above
3100	3150	*2nd Bradford Sandstone*
3100	3110	Siltstone: 60%, as above. Sandstone: 20% as above, a few medium grains. Shale: 20%, light-greenish-gray, silty
3110	3150	Siltstone: 50%, as above. Sandstone: 30%, light-greenish-gray, fine-medium-grained. Shale: 20% as above
3150	3190	Siltstone: 40%, as above. Shale: 60%, light-gray, silty. A little fine-sand
3190	3240	*3rd Bradford Sandstone*
3190	3210	Sandstone: Grayish-white, 90%, fine to medium-grained. Siltstone: 10%, brownish-gray, coarse to fine-grained
3210	3230	Sandstone: 70% as above. Siltstone: 30% as above
3230	3240	Sandstone: 40% as above. Siltstone: 20% as above. Shale: 40%, light-gray, silty
3240	3260	Shale: 70% as above. Siltstone: 20%. Sandstone: 10%
3260	3280	Siltstone: 90%, light-gray, some is greenish, medium-grained. Sandstone: 10%, grayish-white and purplish, very fine-grained
3280	3300	Shale: 75%, light-gray, silty. Siltstone: 20%, light-gray, fine to coarse-grained. Sandstone: 5%, very fine-grained, salt and pepper, purplish
3300	3310	*1st Kane Sandstone*
3300	3310	Sandstone: 60%, grayish-white, fine-grained, a few medium grains. Siltstone: 30%, light-gray, fine-grained. Shale: 10%, light-gray, silty
3310	3330	Shale: 70% as above. Siltstone: 30% as above, to sandy. At 3320 a little dark-gray siltstone (salt and pepper type)
3330	3350	Siltstone: 80%, light-gray, sandy, coarse-grained with some finer. Shale: 20%, light-gray, silty
3350	3370	Siltstone: 70%, light-gray, mostly medium grained, some coarse. Shale: 20%, light-gray, silty. Siltstone: is calcareous. Sandstone: 10%, white-gray, very fine-grained
3370	3540	Not studied
3540	3550	Siltstone: 90%, light-gray, fine to medium-grained, non-calcareous. Shale: 10%, light-gray, slightly silty. Traces of dolomite and very fine pyrite. A few pieces of shale have a brownish cast
3550	3570	Siltstone: 95%; 50% brown and black, salt and pepper texture, coarse-grained; 45% light-gray, medium to fine-grained. Very slightly calcareous

Top	*Bottom*	*Description*
3570	3580	Siltstone: 90%; 70% light-grayish-white, medium to fine-grained; 20% salt and pepper as above. Shale: 10%, light-gray
3580	3730	Not studied
3730	3760	Siltstone: 90%, grayish-white, some has a greenish cast, some gray, medium to fine-grained. Shale: 10%, light-gray. Traces of calcite. 3750—60 traces of salt and pepper siltstone. Slightly calcareous
3760	3790	Siltstone: 95%, light-greenish-gray, some light-gray, calcareous. Shale: 5%, light-gray. Traces of calcite, clear and white rhombs
3790	3800	Siltstone: 100%; 60% light-greenish-gray, medium to fine-grained; 20% gray fine-grained; 20% salt and pepper textured coarse to medium-grained. All slightly calcareous. Traces of calcite
3800	3840	Siltstone: 95%; 50% light-greenish-gray, coarse to medium-grained; 45% medium-gray salt and pepper texture, coarse to medium-grained. Calcareous. Shale: 5%, gray. 1%– calcite. At 3820—40 traces of clear angular quartz grains
3840	3850	Siltstone: 90% as above, but medium to fine-grained. Slightly calcareous. Shale: 10%, light-gray. Traces of calcite and pyrite
3850	4170	Not studied
4170	4190	Siltstone: 90%; 50% light to medium-gray, medium to fine-grained; 40% grayish-white, medium to fine-grained. Shale: 10%, light to medium-gray. Traces of calcareous shale
4190	4210	Siltstone: 90%; 60% grayish-white, medium to fine-grained; 20% light to medium-gray, fine-grained; 10% salt and pepper textured, medium-gray, medium to fine-grained. Some slightly calcareous. Shale: 10%, gray, silty. Traces of calcite, ½ MM fragments, clear and milky
4210	4220	Siltstone: 90%, light to medium-gray, medium to fine-grained, some calcareous. Shale: gray. Traces of calcite and quartz
4220	4230	Siltstone: 100%; 70% grayish-white, medium-grained, calcareous; 30% light to medium-gray, fine-grained. Traces of calcite
4230	4250	Siltstone: 90%, light to medium-gray, some has a greenish cast; medium to fine-grained, some is calcareous. Shale: 10%, gray. Trace of slickensides at 4240
4250	4400	Not studied
4400	4410	Shale: 60%, light to medium-gray, silty, traces of tannish shale. Siltstone: 40%, light-gray, some has a slight greenish cast. Formation is slightly calcareous. Traces of red rock are cavings from up the hole
4410	4420	Shale: as above, 10% tannish shale
4420	4440	Shale: 70%; 50% light-gray, 20% medium-gray, both slightly silty, 5% has a tannish cast. Siltstone: 30%, light-gray, very fine-grained. Traces of pyrite and calcite. Formation is slightly calcareous
4440	4450	Shale: 90%; 60% light-gray, 30% medium to dark-gray, both slightly silty. Formation is non-calcareous, except for traces of calcite. Siltstone: 10%
4450	4460	Shale: 70%; 50% light-gray, 20% medium-gray, slightly silty. Siltstone: 30%, light-gray, fine-grained
4460	4470	Siltstone: 90%, light-gray with slight greenish cast, coarse to fine-grained, calcareous. Shale: 10%, light-gray
4470	4480	Siltstone: 80%, as above, darker in color. Shale: 20%, light-gray, 1—2% dark-gray, silty
4480	4490	Siltstone: 90%, light-gray, with a slight greenish cast, coarse to fine-grained, calcareous. Shale: 10%, light-gray
4490	4520	Siltstone: 80% as above. Shale: 20%, light-gray, traces of dark gray, silty

Top	*Bottom*	*Description*
4520	4530	Siltstone: 90%, light-gray with a slight greenish cast, fine-grained, calcareous. Shale: 10%, light-gray, with traces of dark gray
4530	4550	Siltstone: 80%, light-gray, fine-grained, calcareous, shaly. Shale: 20%, light-gray. Traces of slickensides
4550	4560	Siltstone: 80%, light-gray, fine-grained. Shale: 20% light gray. Traces of medium-gray salt and pepper siltstone. Traces of calcite. Calcareous
4560	4570	Siltstone: 90% as above, with 1% medium-gray salt and pepper siltstone. Shale: 10% as above
4570	4580	Siltstone: 90%, light-gray, medium to fine-grained, 1% dark-gray salt and pepper siltstone, calcareous. Traces of calcite and very small pyrite crystals
4580	4590	Siltstone: 90%, light-gray, fine-grained, traces of salt and pepper siltstone. Shale: 10%, as above
4590	4600	Siltstone: 90%, light-gray, fine-grained, occasional piece of salt and pepper siltstone. Shale: 10%, as above
4600	4610	Siltstone: 90%, light-gray, fine-grained, a little medium gray and shaly. Calcareous. Shale: 10%, light-gray
4610	4620	Siltstone: 90%, light-gray with a slight greenish cast, fine-grained, 5%, medium-gray siltstone
4620	4630	Siltstone: 70%, as above. Shale: 30%, light-gray, slightly silty
4630	4650	Siltstone: 90%, light-gray, fine-grained, shaly. Shale: 10%, light-gray. Formation is slightly calcareous
4650	4670	Shale: 80%, light-gray, silty. Traces of medium and dark-gray shale. Siltstone: 20%, light-gray, fine-grained. A few pieces slightly calcareous
4670	4690	Shale: 80%, light-gray, silty. Traces of medium-gray shale. Siltstone: 20%, light-gray, fine-grained, 1—2% dark-gray, salt and pepper texture, medium grained. Traces of calcite and calcareous siltstone
4690	4720	Shale: 80%, light-gray, silty, traces of medium-gray. Siltstone: 20%, light-gray, fine-grained, traces of salt and pepper siltstone: Traces of brownish shale, has slickensides and may be associated with faulting
4720	4730	Shale: 70%, as above. Siltstone: 30%, traces of dark shale
4730	4750	Shale: 60%, light-gray, with a little medium and dark-gray, all silty. Siltstone: 40%, light-gray, fine-grained
4750	4770	Shale: 90%, light-gray, slightly silty, traces of dark and medium-gray. Siltstone: 10% as above
4770	4780	Shale: 70%, as above. Siltstone: 30%, light-gray, coarse to fine-grained
4780	4790	Siltstone: 80%, dark-gray, salt and pepper texture, coarse to fine-grained, moderately calcareous. Shale: 20%, light-gray, traces of calcite
4790	4800	Shale: 90%, light-gray, silty. Siltstone: 10%. Traces of calcite and of overlying siltstone
4800	4810	Siltstone: 60%, light-gray, coarse-grained. Shale: 40% light-gray, traces of dark gray
4810	4820	Siltstone: 70%, dark-gray to black, coarse-grained, salt and pepper texture, slightly calcareous. Shale: 30%, tannish-gray. Traces of calcite
4820	4910	Shale: 70%, light-gray, some is silty. Siltstone: 30%, light-gray
4910	4930	Siltstone: 60%, light-gray, some has a greenish cast, fine- to medium-grained. Shale: 40%, light-gray. Formation is calcareous. 1% calcite
4930	4940	Siltstone: 70%, light-gray to dark-gray, 5% salt and pepper textured. Shale: 30%, light to medium-gray, slightly calcareous, traces of calcite
4940	4960	Siltstone: 50%, light to medium-gray, fine-grained. Shale: 50%, light-gray, traces of dark-gray. Traces of calcite

Top	*Bottom*	*Description*
4960	5010	Siltstone: 60%, light to medium-gray with a greenish cast, 1-2%, salt and pepper textured dark-gray. Shale: 40% light-gray, some has brownish cast. Traces of calcite. 4990—trace of pyrite
5010	5070	Siltstone: 75%, light-greenish-gray, fine-grained, traces of medium-gray siltstone and poor salt and pepper siltstone. Shale: 25%, light-gray, some slightly silty. Trace of calcite
5070	5100	Siltstone: 80%, light-greenish-gray to gray, fine to medium-grained. Shale: 20%, light-gray. Traces of calcite. Formation very slightly calcareous
5100	5120	Siltstone: 70%, gray, some has a slightly greenish cast, fine-grained, silty. Shale: 30%, light-gray. Traces of medium-gray, silty shale
5120	5160	Siltstone: 60%, light-gray, coarse to fine-grained, shaly. Shale: 40%, light to medium-gray, slightly silty
5160	5200	Siltstone: 70%, as above, shaly. Shale: 30% as above
5200	5210	Siltstone: 75%, medium-gray, fine-grained, shaly; 25%, light-gray, fine-grained, with a greenish cast
5210	5220	Siltstone: 90%; 50%, medium and light-gray, fine-grained, shaly; 40%, light-gray, with a greenish cast, fine-grained; traces of medium-gray salt and pepper siltstone. Shale: 10%, light-gray, slightly silty
5220	5250	Siltstone: 60%, light to medium-gray, some slightly green, fine-grained, shaly. Shale: 40%, light-gray, silty
5250	5260	Siltstone: 75%; 50% medium-gray, fine-grained, shaly; 25% light-gray with greenish cast, fine-grained. Shale: 25% light to medium-gray, some is silty, traces of a tannish shale, formation is slightly calcareous; calcite in the siltstone
5260	5280	Siltstone: 80%; 40%, light-gray, fine-grained; 40% medium-gray, fine-grained, shaly; 1% grayish-white, medium-grained. Shale: 20%, light to medium-gray, silty. 5270-5280 trace of medium-gray salt and pepper siltstone
5280	5300	Siltstone: 95%; 35% light-gray, some is greenish, fine-grained; 60% medium-gray, fine-grained, shaly. Shale: 5%, light-gray. Traces of slickensides
5300	5310	Shale: 80%, light to dark-gray, some has a brownish cast, many pieces have slick surfaces. (Suspect faulting in area.) Siltstone: 20%, whitish to light-gray, fine to medium-grained. Traces of tiny pieces of calcite
5310	5340	Siltstone: 60%, light-gray, fine-grained, some is shaly. Shale: 40%, light-gray, some is silty. 5320– 40—1%± of grayish-white siltstone, slightly calcareous
5340	5350	Siltstone: 90%; 70% light-gray, fine-grained; 30% light gray, with a greenish cast, medium-grained. Shale: 10%, light-gray, silty
5350	5360	Siltstone: 80%; 40% white to light-gray with a greenish cast, medium to fine-grained; 40% light and some medium-gray siltstone, fine-grained. Shale: 20%, slightly silty
5360	5370	Shale: 60%, medium-gray, a little light-gray, some is silty. Siltstone: 40%, medium-gray, medium to fine-grained, some is greenish siltstone
5370	5390	Siltstone: 80%; 60% light-gray and some medium-gray, fine-grained; 20% light-grayish-white with greenish casts, fine- to medium-grained. Shale: 20%, light-gray, some silty. Trace of brown shale with slickensides
5390	5410	Siltstone: 95%; 80% medium-gray, fine to medium-grained; 15% light-greenish-gray, medium-grained; a little siltstone, light-brownish-gray, medium-grained. Shale: 5%, light to medium-gray, silty, trace of light-green shale. Traces of slickensides and reddish siltstone (cavings). At 5390-5400 siltstone: 1%, light-brownish-gray, medium-grained, traces of slickensides and reddish siltstone

Top	*Bottom*	*Description*
5410	5430	Siltstone: 95%; 70% medium-gray, fine to medium-grained. 25% light-greenish-gray, medium-grained. Shale: 5%, light to medium gray
5430	5470	Siltstone: 80%, light to medium-gray, fine-grained, some greenish-gray. Shale: 20%, light to medium-gray, some is silty
5470	5490	Siltstone: 50% as above. Shale: 50% as above. Traces of slickensides, dark gray siltstone
5490	5610	Siltstone: 50%, light to medium-gray, very fine-grained, shaly. Shale: 50%, light to medium-gray, some is silty. Slickensides at 5510. At 5570 traces of clear, sharp quartz grains and calcite. From 5560-5610—10%± greenish-gray siltstone
5610	5620	Shale: 70%, light to medium-gray, some is silty. Siltstone: 30%, grayish-white to medium-gray
5620	5640	Siltstone: 70%, grayish-white with a slight greenish cast, a little light-gray, medium to fine-grained. Shale: 30%, light-gray, silty
5640	5650	Siltstone: 60%, grayish-white to medium-gray, mostly fine-grained. Shale: 40%, medium-gray, some slightly silty. A few pieces of red rock cavings
5650	5660	Siltstone: 60%, half grayish-white, medium to fine-grained, half medium-gray, fine-grained. Shale: 40%, light to medium-gray, some is silty
5660	5680	Siltstone: 80%, half grayish-white, medium to fine-grained, half, light to medium-gray, fine-grained. Shale: 20%, light to medium-gray, mostly all silty
5680	5720	Siltstone: 90%, ⅔ grayish-white, medium to fine-grained, ⅓ light to medium-gray, fine-grained. Shale: 10%, light-gray
5720	5740	Shale: 80%, mostly medium-gray, some is silty. Siltstone: 20%, grayish-white to medium-gray. Trace of slickensides, quartz fragment
5740	5750	Siltstone: 80%; 60%, grayish-white with a greenish cast, medium to fine-grained; 20%, gray, fine-grained. Shale: 20%, light-gray
5750	6100	Not studied
6100	6130	Siltstone: 60%, light-gray, mostly fine-grained, shaly. Shale: 40%, light to medium-gray slightly silty. Traces of slickensides at 6110. Occasional fragment of pyrite
6130	6160	Siltstone: 80%, light-gray, some has a greenish cast, coarse to fine-grained. Shale: 20%, light to medium-gray, silty
6160	6170	Shale: 60% as above. Siltstone: 40% as above
6170	6200	Siltstone: 70%; 50% light-gray, as above; 20% medium to dark-gray, shaly. Traces of pyrite. At 6180-6200 traces of gouge material
6200	6220	Siltstone: 70%, grayish-white, medium-gray to light-gray, fine-grained, non-calcareous. Shale: 30%, light-gray, slightly silty
6220	6270	Siltstone: 80%, greenish-white, medium-grained; light to medium-gray, fine-grained. Shale: 20%, light-gray, slightly silty
6270	6300	Siltstone: 80%, mostly light-gray, some grayish-white, a little medium-gray, fine-grained. Shale: 20%, light-gray
6300	6320	Siltstone: 70%, grayish-white, light and medium-gray with some dark-gray, fine-grained, shaly, non-calcareous. Shale: 30%, light-gray, slightly silty
6320	6330	Siltstone: 70%, grayish-white, light-gray, some medium-gray, fine-grained, shaly. Shale: 30%, light-gray
6330	6340	Siltstone: 90%, mostly grayish-white (slightly greenish), a little light and medium-gray, fine-grained. Shale: 10%, light-gray
6340	6390	Siltstone: 80%, grayish-white, light to medium-gray, mostly fine-grained. Shale: 20%, light-gray. At 6370— trace of brown shale and gouge, light-greenish coarse-grained siltstone. Formation slightly calcareous

Top	*Bottom*	*Description*
6390	6400	Siltstone: 70%, light to medium-gray, a little grayish-white, trace of pyrite. Shale: 30%, light-gray, slightly silty
6400	6410	Siltstone: 80%, light to medium-gray, a little dark-gray and grayish-white. Shale: 20%, light-gray
6410	6440	Shale: 70%, light to medium-gray, a little dark-gray, some slightly silty. Siltstone: 30%, gray, fine-grained. Traces of tannish shale. Formation is non-calcareous
6440	6510	Siltstone: 80%, light-grayish-white to medium-gray, fine to medium-grained. Shale: 20%, light to medium-gray. Traces of dark-gray siltstone. At 6460 traces of gouge
6510	6600	Siltstone: 70%; 60%, light to medium-gray, some greenish, fine-grained; 10% dark-gray to black, very fine-grained. Shale: 30%, light to medium-gray, some slightly silty. Trace of slickensides. At 6540 traces of dark-gray salt and pepper siltstone. Formation is non-calcareous. At 6570 trace of light-brownish shale, resemble tully
6600	6630	Siltstone: 80%; light to medium-gray, a little has a greenish cast, fine to medium-grained, 5% dark-gray. Shale: 20%, light to medium-gray, a few pieces have dark inclusions. Traces of gouge. Occasional piece of pyrite. At 6630— % of medium-gray increases over light gray
6630	6640	Siltstone: 80%, mostly medium-gray, some light and dark-gray, fine-grained, some medium-grained. Shale: 20%, light to medium-gray. Traces of gouge
6640	6650	Siltstone: 70%, light to medium-gray, a little dark, very fine to medium-grained. Shale: 30%, medium to dark-gray. Traces of gouge. Some of the siltstone has a greenish cast
6650	6660	Siltstone: 60%, grayish-white, coarse-grained, sandy. Shale: 40%, light to medium-gray, some dark-gray
6660	6670	Shale: 70%, medium-gray, a little slightly silty. Siltstone: 30%, light to medium-gray, fine to medium-grained
6670	6690	Shale: 50%, light to medium-gray. Siltstone: 50%, light to medium-gray, fine-grained
6690	6710	Shale: 75%, light to medium-gray. Siltstone: 25%, as above
6710	6780	Siltstone: 70%, light to medium-gray, a little dark-gray, very fine-grained
6780	6800	Siltstone: 90%, light to medium-gray, some has a greenish cast, non-calcareous. Shale: 10%, light-gray
6800	6820	Siltstone: 60%, light-gray and some medium-gray, fine-grained. Shale: 40%, light to medium-gray, silty
6820	6830	Shale: 70%, light, but mostly gray, slightly silty. Siltstone: 30%, as above
6830	6840	Siltstone: 80%, light to dark-gray, very fine-grained, shaly. Shale: 20%, medium-gray, slightly silty
6840	7850	Spot checked
6800	6810	Siltstone: 60%, light-gray, very fine-grained, traces of medium-gray. Shale: 40%, light-gray
6900	6910	Shale: 80%, medium-gray, some light-gray. Siltstone: 205, as above. Formation is non-calcareous
6690	6700	Shale: 70%, light-gray, silty. Siltstone: 30% light-gray, very fine-grained. Formation very slightly calcareous
7000	7010	Shale: light to medium-gray. Siltstone: 10%—, light-gray, very fine-grained. Traces of calcareous shale
7060	7070	Shale: 80%; 70% medium, 30% dark-gray. Siltstone: 20%, light-gray, very fine-grained
7070	*Top of dark gray shale*	
7070	7080	Shale: 90%; 70% dark, 20% medium-gray. Siltstone: 10%, as above.
7080	7090	Shale: 95%; 80% dark, 15% medium-gray. Siltstone: 5%, as above. Formation is non-calcareous
7110	7120	Shale: 60% dark, 40% medium-gray, slightly silty

Top	*Bottom*	*Description*
7200	7210	Shale: 60%, dark and a little medium-gray. Siltstone: 40%, light-gray, fine-grained
7300	7310	Shale: Dark-gray, silty, very slightly calcareous. Traces of siltstone (sample from mud from the end of 7″ at 7310)
7400	7410	Shale: 80%, medium to dark-gray. Siltstone: 20%, light-gray, very fine-grained
7440	7450	Shale: as above, pyritic and slightly calcareous
7490	7500	Shale: 90%, mostly dark-gray, some light and medium, silty, pyritic. Trace of calcite. Formation slightly calcareous. Siltstone: 10%—, light-gray, fine-grained
7500	7510	Shale: 95% dark-gray, silty, traces of pyrite and calcite. Siltstone: 5%. Non-calcareous
7540	7550	Shale: 95%; 75% dark-gray, 20% medium-gray, silty, trace of calcite. A few pieces of shale are very slightly calcareous. Siltstone: 5%
7600	7610	Shale: 95%; dark-gray, silty, traces of calcareous shale. Trace of calcite and pyrite. Siltstone: 5%
7650	7660	Shale: 95%, dark-gray, silty, traces of slightly calcareous shale. Traces of calcite. Siltstone: 5%
7700	7710	Shale: 95%, dark-gray, some calcareous, some medium-gray. Traces of pyrite and calcite
7720	7730	Shale: as above, quite calcareous
7730	7740	Shale: as above, non-calcareous
7740	7750	Shale: 50%, dark-gray, silty. Limestone: 50% light-grayish-brown, silty, very fine. (Judging limestone by calcium carbonate contact as well as color)
7850	7940	*Tully Limestone*
7850	7900	Limestone: Tully 80% dark-gray limestone, some fragments more silty than others; 15% dark-gray, silty shale; trace of pyrite and calcite; about 5% of limestone is light-brown limestone; ± 5% black-shale
7900	7920	Limestone: as above, about 10% good dark-gray limestone; 60% dark-gray silty lime; 30% silty shale; fine fragments of limestone have a brownish cast.
7920	7940	Limestone: as above, becoming more silty with traces of pyrite
800′		MIDDLE DEVONIAN SERIES
7940	8260±	*Hamilton Formation*
7940	7950	Shale: 80% dark-gray silty shale; 20% medium-gray, silty shale; slightly calcareous; traces of pyrite
7950	8200	Shale: dark-gray; traces of pyrite and silty limestone
8200	8220	Shale: dark-gray; traces of pyrite and white siltstone
8220	8250	Shale: dark-gray and black, more black shale than above, traces of white siltstone, calcite and pyrite
8250	8260	Shale: 50% dark-gray shale; 50% medium-gray shale, a few fragments of dark-gray shale contains large quantities of pyrite
8260	8270	Shale: 90% dark-gray; 10% medium-gray; traces of calcite
8270	8300	Shale: black, traces of calcite
8300	8310	Shale: black (as above) with traces of green shale and calcite (shale is extremely calcareous)
8310	8330	Shale: black (as above) non-calcareous, traces of calcite and light-gray shale
8330	8340	Shale: black (slightly calcareous)
8340	8360	Shale: dark-gray to black (non-calcareous); traces of calcite and pyrite
8360	8370	Shale: dark-gray to black; traces of pyrite and calcite (shale is calcareous)
8370	8380	Shale: black (calcareous).
8380	8450	Shale: black, larger amounts of pyrite; trace of brown shale (calcareous)

Top	*Bottom*	*Description*
8450	8470	Shale: 100%, black, 90% slightly calcareous; 10% very calcareous. Traces of pyrite and calcite. Cuttings coarse
8470	8500	Shale: as above, cuttings fine to coarse; % of pyrite increasing. 50% very slightly calcareous; 50% very calcareous
8500	8510	Shale: 100%, black, cuttings fine to coarse; 60% very calcareous and these are mostly the fine cuttings. 40% very slightly calcareous
8510	8520	Shale: 100%, black, cuttings ½ fine, ½ coarse. Calcareous as above. Pyrite and calcite present
8520	8530	Shale: as above, 1% pyrite and calcite
8538	*Top Brown Bentonite*	
8530	8540	Shale: very calcareous, black. 2% calcite. Traces of bentonite that is very pyritic. (Top would be about 8538, sample caught too quickly)
8540	8550	Shale: 50% black. Limestone: 50% black, very shaly. Traces of bentonite
8548	8570	*Onondaga Limestone*
8550	8554	Limestone: 50%, black Onondaga. Shale: 40%, black, calcareous. Bentonite: 10%. (Top would be about 8548, because samples caught early and sample log)
8554	8555	Limestone: 50% black. Shale: as above and bentonite as above
8555	8570	Limestone: 50% black. Shale: 50%, black, calcareous. Traces of Bentonite. (In 65-70 sample, caught properly, Trace of chert)
8570	8571	Limestone: 60%. Shale: 35%. Chert: 5%. (Top will be at 8570 by drilling and samples)

Sample log of A. A. Dupre no. 1 well (Cc10)
Mid-Atlantic Oil & Gas Company

Author unknown

FORMATION	COLOR	TOP	BOTTOM	REMARKS
No samples taken		0	455	
Sandstone	white	455	475	
Shale	brownish-gray	475	500	
Sandstone	white	500	515	
Shale	gray-tan	515	524	
Sandstone	white	524	544	
Siltstone	gray	544	564	
Limestone	lt. brown	564	575	
Shale	lt. gray	575	583	
Limestone	gray	583	600	
Sandstone	white	600	606	
Siltstone	gray	606	815	
Shale	red	815	893	
Siltstone	red	893	975	
Limestone	white	975	980	
Siltstone	reddish & gray	980	1156	1135 small
Silt	red	1156	1170	amt. fine sand
Sandstone	salt & pepper	1170	1198	very fine
Siltstone	gray & red	1198	1222	
Sandstone	red & brown	1222	1297	
Shale	lt. gray	1297	1306	
Silt	sand	1306	1334	
Sandstone	white and gray	1334	1354	
Silt	white	1354	1367	
Siltstone	gray-greenish	1367	1375	
Bayard Sandstone	grayish-white	1375	1405	
Shale	lt. gray	1405	1454	

Top Bottom	*Description*			
FORMATION	COLOR	TOP	BOTTOM	REMARKS
Bayard Stray Sandstone	gray	1454	1460	
Shale	lt. gray	1460	1550	
Siltstone	white	1550	1608	
Shale	lt. gray	1608	1635	
Sandstone	salt & pepper	1635	1660	1690-1704 few large quartz grains
Siltstone	lt. green-gray	1660	1720	
Siltstone	lt. reddish brown	1720	1762	
Shale	lt. gray	1762	1810	
Sandstone	white	1810	1840	
Shale	lt. gray	1840	1878	
Siltstone	white-lt. green	1878	1943	
Shale	mod. red	1943	1953	
Speechley Sandstone	white-red-lt. gray	1953	1976	
Siltstone	white-lt. green	1976	2010	
Shale	mod. red-green gray	2010	2025	
Siltstone	mod. red-green gray	2025	2034	
Shale	mod. red-green gray	2034	2045	
Tiona Sandstone	lt. greenish gray	2045	2135	
Shale	med. gray	2135	2165	
Siltstone	lt. gray	2165	2183	
Shale	med. lt. gray	2183	2210	
Siltstone	med. lt. gray	2210	2330	
Sheffield Sandstone	white	2330	2362	
Shale	med. lt. gray-black	2362	2385	
1st Bradford Sand	white	2385	2418	
Shale	med. gray to dark	2418	2445	
2nd Bradford Sand	white	2445	2490	
Shale	lt. gray-red	2490	2548	
Siltstone	med. gray	2548	2580	
3rd Bradford Sand	white	2580	2660	
1st Kane Sand	white to dark gray	2660	2682	
Shale	gray	2682	3046	
Siltstone	lt. gray to black	3046	3056	
Shale	lt. gray to med. gray	3056	3286	
Siltstone	med. lt. gray	3286	3550	
Shale	med. lt. gray	3550	3575	
Siltstone	lt. gray	3575	3800	Traces of calcareous fossil fragments.
Shale	lt. gray	3800	3842	
Siltstone	gray-grayish brown	3842	3856	
Shale	lt. to dark gray	3856	3952	
Siltstone	dark gray	3952	4028	
Shale	lt. gray	4028	4065	
Siltstone	lt. gray	4065	4146	
Limestone	white & lt. gray	4146	4170	fossil zone
Siltstone	lt. gray	4170	4260	
Shale	lt.-med. gray	4260	4508	
Siltstone	dark gray to black	4508	4540	
Shale	lt. gray	4540	4583	
Siltstone	lt. to dark gray	4583	4625	
Shale	med. gray	4625	4662	
Siltstone	lt. gray to black	4662	4720	
Shale	lt. gray	4720	4733	
Siltstone	med. gray-pink-white	4733	4750	
Shale	med. gray-yell-brn.	4750	4855	
Siltstone & Shale	lt. gray to black	4855	6500	
Shale	lt. to med. gray	6500	8170	
Onondaga Chert and Limestone	lt. blue gray-black	8170	8355	
Oriskany Sand	white to gray-black	8355	8385	TOTAL DEPTH
Helderberg Limestone	lt. gray to black	8385	8477	

SURFACE ROCKS

The thickness of strata exposed in the Donegal quadrangle is about 2250 feet, and represents the section from the lower part of the Mississippian system to the top of the Pennsylvanian system. The composite stratigraphic section shown on Plate 1 was compiled from measurements of partial exposures at various places in the quadrangle, and shows averaged thickness. Areal distribution of the geologic formations and their contacts are also shown on Plate 1. The general descriptions of the subdivisions within the Mississippian and Pennsylvanian systems follows. The units in these subdivisions which are considered to have the best economic potential are considered in more detail under "Mineral Resources."

Figure 1. The Pennsylvania Turnpike through Chestnut Ridge looking west from location Ab 13.

Mississippian System

The Mississippian system of rocks in the Donegal quadrangle is composed of the three lithologic units. The Pocono Group in the lower part of the section includes two units—a thick formation (unnamed) of sandstone beds alternating with minor siltstones and shales, over which is the Loyalhanna Formation composed of siliceous limestone. The dominantly red Mauch Chunk Formation, which contains the Greenbrier marine limestone Member in the lower part makes up the upper part of the Mississippian beds.

The largest outcrop area of Mississippian rocks is on Laurel Hill where the units are about 870 feet thick. Mississippian rocks also crop out on Chestnut Ridge as inliers in the deep ravines of the west limb of the anticline. The thickness of Mississippian rocks on Chestnut Ridge is about 980 feet.

Although the entire section of Mississippian rocks is not completely exposed in the Donegal quadrangle, excellent exposures do occur in the gorges of Laurel Hill and Chestnut Ridge in the Johnstown and New Florence quadrangles. Fettke and Bayles measured and described those sections which were subsequently included in the Pennsylvania Geologic Atlas no. 57 (Shaffner, 1958).

Pocono Group

Burgoon Sandstone

The section of sandstones and shales in the Pocono Group below the Loyalhanna Formation is about 500 feet thick in Laurel Hill. Most of these rocks crop out in the steep hillsides above Trout Run on the west limb of the anticline, but they are poorly exposed. The upper unit, the Burgoon sandstone, is also the Big Injun sand of the oil and gas well drillers. The upper part of the Burgoon sandstone is exposed on the west limb of Laurel Hill in the vicinity of Myersbrook, and on the east limb of the anticline along Mill Run, about 2 miles south of Mt. Hope Church. The Burgoon sandstone in those localities varies from a fine-grained, thin-bedded, greenish-gray rock containing scattered mica flakes, to a massive, medium- to coarse-grained, gray to whitish sandstone which is locally conglomeratic.

The Burgoon sandstone crops out as small inliers on the west limb of Chestnut Ridge below Idemiller quarry (Ba 12) in Unity Township, and in GreenLick Run, Mounts Run, and below Gerry School in Bullskin Township. Detailed description of the Pocono Group in Chestnut Ridge is given in the sample study log of the Musnug no. 2 well (Ba 10) on page 10.

Loyalhanna Formation

The Loyalhanna Formation at the top of the Pocono Group has been called a siliceous limestone although its quartz content is approximately 50 percent of the rock, and in some cases may exceed that amount. Hickok (Hickok and Moyer, 1940) reported the Loyalhanna to be composed predominantly of quartz grains cemented by calcite with minor amounts of tourmaline, biotite, chlorite, feldspar, alivine (?), and black opaque mineral grains. By way of contrast, the caves which have been found in the Loyalhanna at places in Fayette and Westmoreland Counties (Stone, 1932) are evidence of its calcareous composition.

In the Donegal quadrangle the Loyalhanna is light gray to bluish gray on the fresh surface, and weathers dark gray. Cross-bedding which is a characteristic feature of the rock, is scarcely discernible on the fresh surface, but on the weathered surface it becomes strikingly conspicuous. Due to differential weathering, the resistant laminations protrude as rounded edges and the more soluble ones have groove-like edge. Also because of its solubility its outcrop is generally concealed by brown sandy soil which forms a relatively mild-sloping surface.

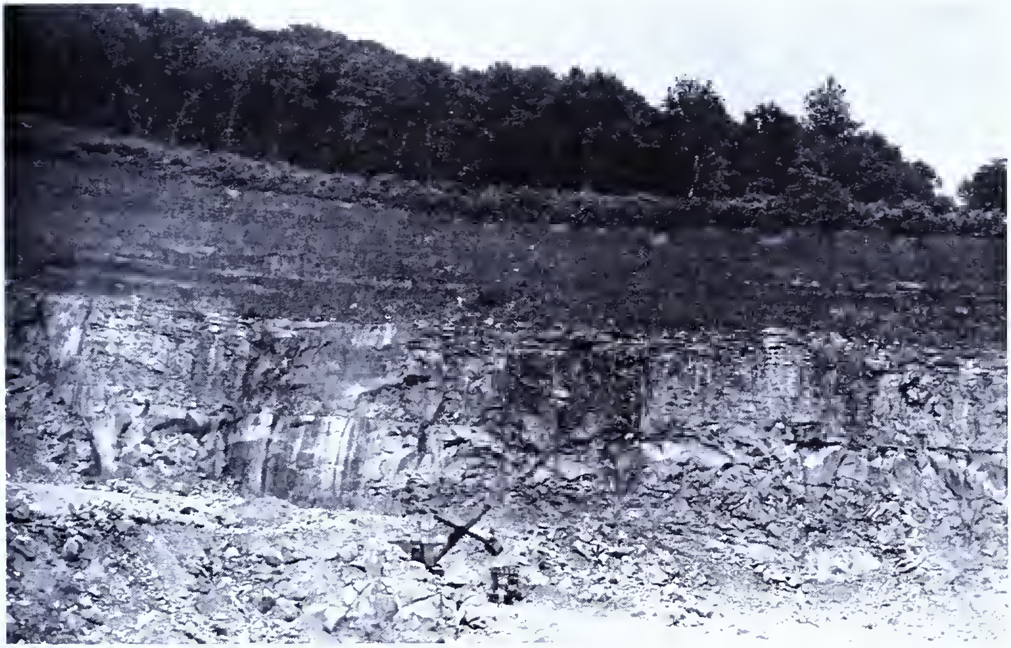


Figure 2. The Loyalhanna Limestone in the Idemiller quarry (Ba 12) overlain by red beds of the Mauch Chunk Formation.

The contact of the Loyalhanna Formation and the underlying Burgoon sandstone was seen at a few places; there is a distinct line of demarcation between the respective typical lithologies. The contact of the top of the Loyalhanna with the overlying Mauch Chunk Formation is similarly definite, with red shale or siltstone commonly lying on top of cross-bedded siliceous limestone. Sandstone at the base of the Mauch Chunk is locally the contact material with the top of the Loyalhanna.

The Loyalhanna Limestone is persistent throughout the Donegal quadrangle, and it crops out extensively on Laurel Hill. The formation is 59 feet thick in the active quarry of the Somerset Lime Company on Pa. Route 31 at the eastern boundary of the quadrangle (Cc 4). The Loyalhanna crops out as inliers on the west limb of Chestnut Ridge. A large quarry in the north-central part of the quad-

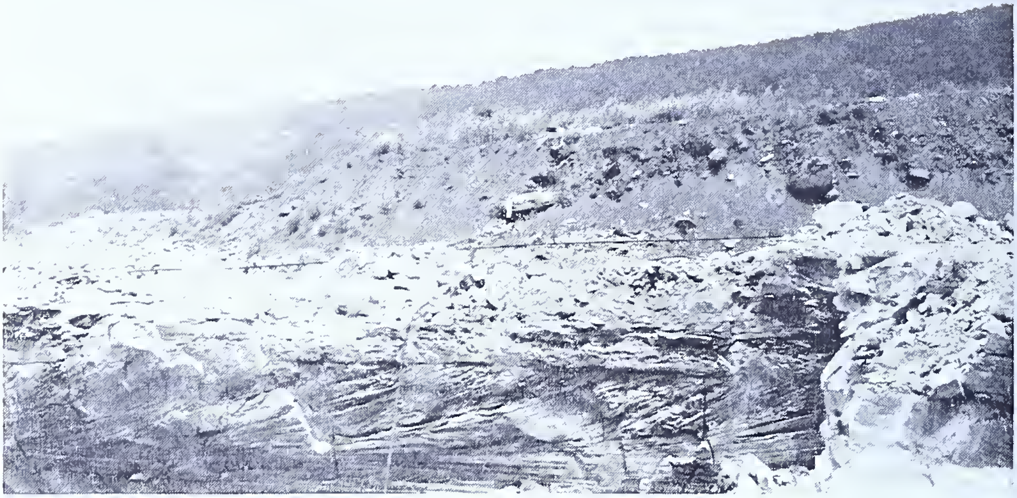


Figure 3. Loyalhanna limestone beds showing typical crossbedding. At the Idemiller quarry (Ba 12).

rangle (Ba 12) operated by the Idemiller Enterprises is presently active. The Loyalhanna there has a maximum thickness of 79 feet.

Mauch Chunk Formation

The Mauch Chunk Formation consists mostly of a sequence of red shales and siltstones with intercalated beds of gray shales, gray sandstones, greenish flaggy siltstones, and the Greenbrier Limestone Member in the lower part of the formation. Although outcrops and exposures of Mauch Chunk are common in the Donegal quadrangle, at no place is the entire section now exposed. Details of the lithology of the Mauch Chunk in the sample study log of the Musnug no. 2 well (Ba 10) is given on page 9.

The thickness of the Mauch Chunk in Chestnut Ridge is from 160 to 190 feet in the north-central part of the quadrangle; and from 200 to 225 feet in the west-central part of the quadrangle. The unconformable Mauch Chunk-Pottsville contact is clearly visible on the east limb of Chestnut Ridge on the north side of the Turnpike. Excellent exposure of the Loyalhanna-Mauch Chunk contact is to be seen in the Idemiller quarry (Ba 12).

Outcrops of the Mauch Chunk Formation cover large irregular areas on Laurel Hill. Arthur B. Cleaves (personal communication) measured the thickness of the Mauch Chunk during construction of the Laurel Hill tunnel and recorded 250 feet. A thickness of 300 feet of Mauch Chunk is indicated in the driller's log of a well drilled for natural gas on the east limb of Laurel Hill in the southeastern part of the quadrangle.

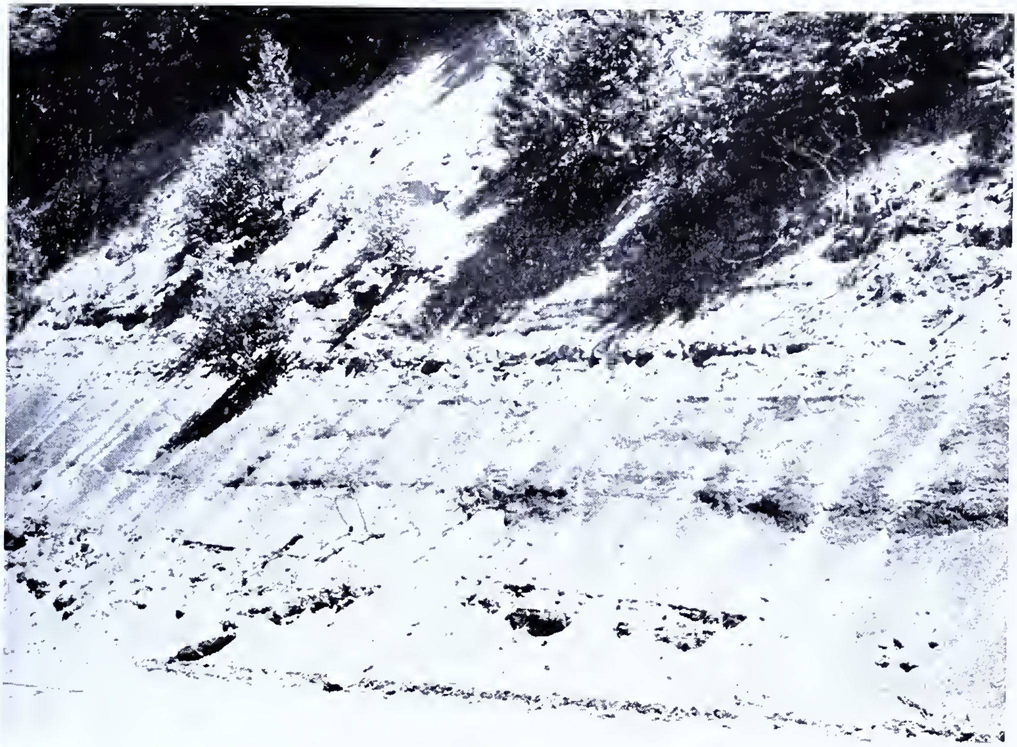


Figure 4. Red beds of the Mauch Chunk Formation as exposed along the Pennsylvania Turnpike (Ab 16).

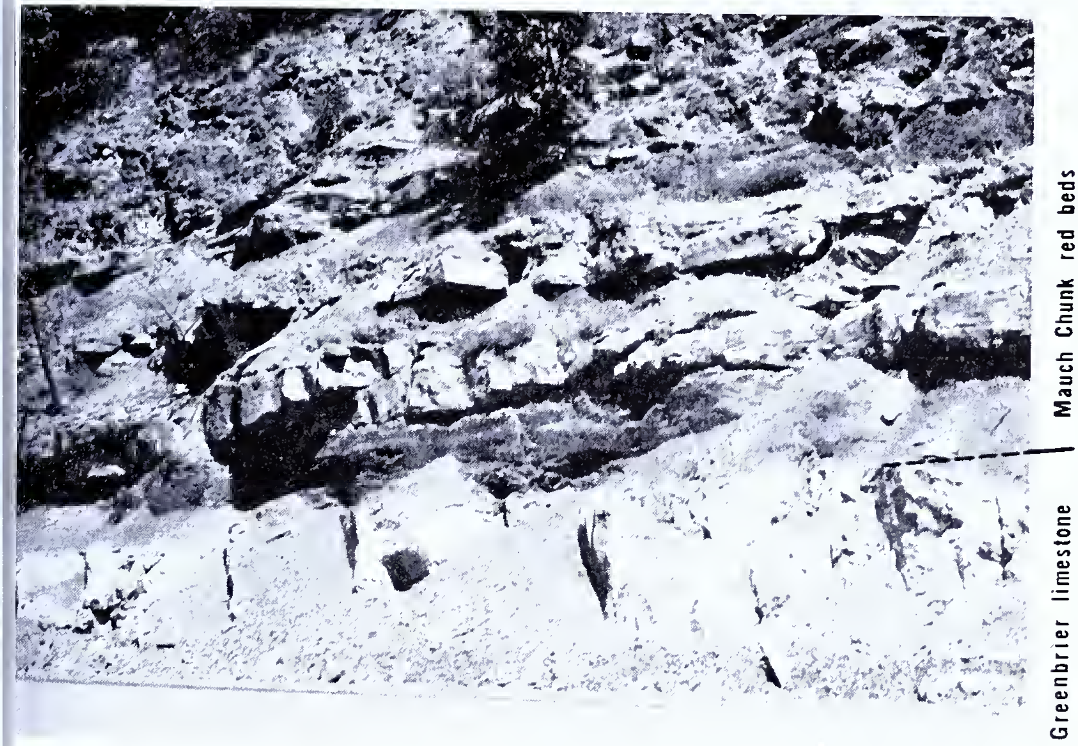


Figure 5. Contact between the Greenbrier limestone and the Mauch Chunk red beds.

The Mauch Chunk-Loyalhanna contact is visible on the west limb of Laurel Hill along the Turnpike and in the quarry of the Somerset Lime Company on Pa. Route 31 (Cc 4).

Greenbrier Limestone Member. The top of the Greenbrier Member is about 75 feet above the top of the Loyalhanna Formation. The thickness as measured along the north side of the Turnpike through Chestnut Ridge (Ab 13) is 24 feet. The upper 14 feet consists of a massive, thick-bedded, dark-bluish-gray limestone, the lower 10 feet consists of alternating thin beds of light-bluish-gray limestone and calcareous shale. Fossils are abundant in the lower part and sparse in the upper part. The fossils are mostly brachiopods and crinoid stems with an occasional trilobite.

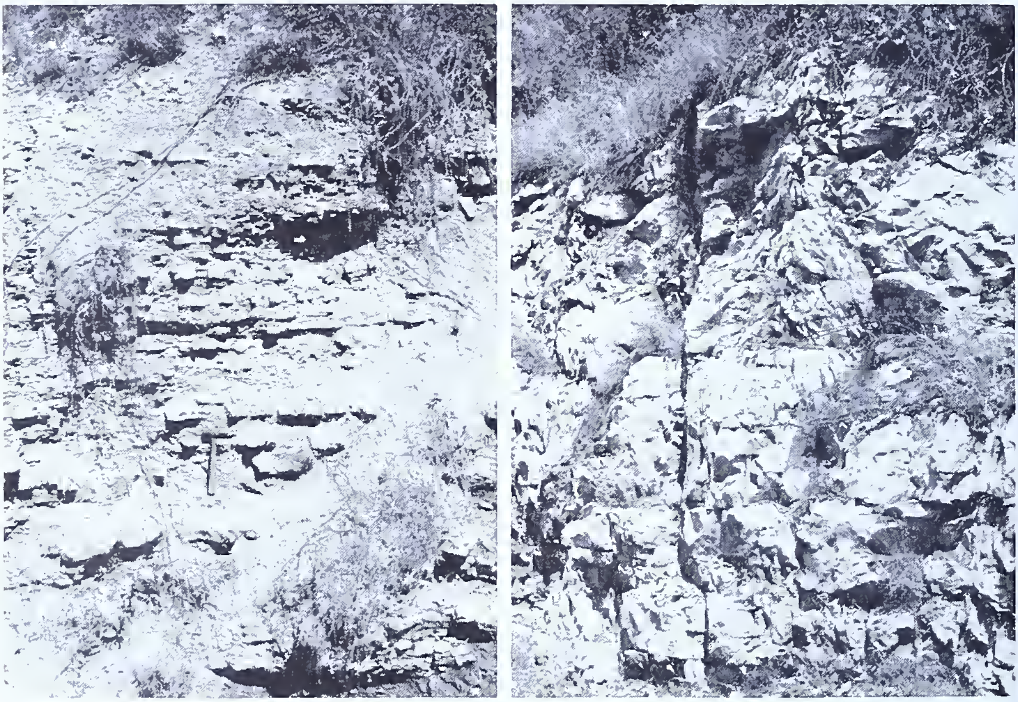


Figure 6. The Greenbrier limestone in the Mauch Chunk Formation as exposed at Ab 13. Photo on the right shows the massive upper beds; photo on the left shows thin-bedded lower beds.

Continuity of the Greenbrier along its outcrop on Chestnut Ridge and Laurel Hill is indicated by abandoned open pits and drifts where farmers had worked the limestone for agricultural use.

Pennsylvanian System

Pottsville Group

The Pottsville Group is composed largely of massive, irregularly bedded sandstones. They are white or various shades of gray, fine- to coarsed-grained, and locally conglomeratic. Fossil plant impressions and carbonized plant remains are occasionally present. The sandstones are separated by thin beds and lenses of silty shale.

The Pottsville Group rests unconformably upon the eroded surface of the Mauch Chunk Formation.

In the Donegal quadrangle, the Pottsville Group is poorly exposed, so that formations as such cannot be mapped. The rock units which are present, however, are believed to belong to four formations which are mapped in other areas of western Pennsylvania.

A discontinuous local coal and associated underclay at the base of the section are assigned to the Sharon Formation, the correlation being based solely on their position in the section. Above this coal, and locally with thin shales intervening, is a sandstone section which averages 150 feet in thickness. Locally, this sandstone body is split into two bodies by a coal and clay layer equated to the Quakertown coal. The sandstone body and the associated Quakertown coal and clay are included in the Connoquenessing Formation, the sands being called the upper Connoquenessing and the lower Connoquenessing when split. Above the Connoquenessing Formation is the Mercer Formation containing an underclay, a poor coal, and overlying shales in a section averaging 20 feet in thickness. This formation is capped by

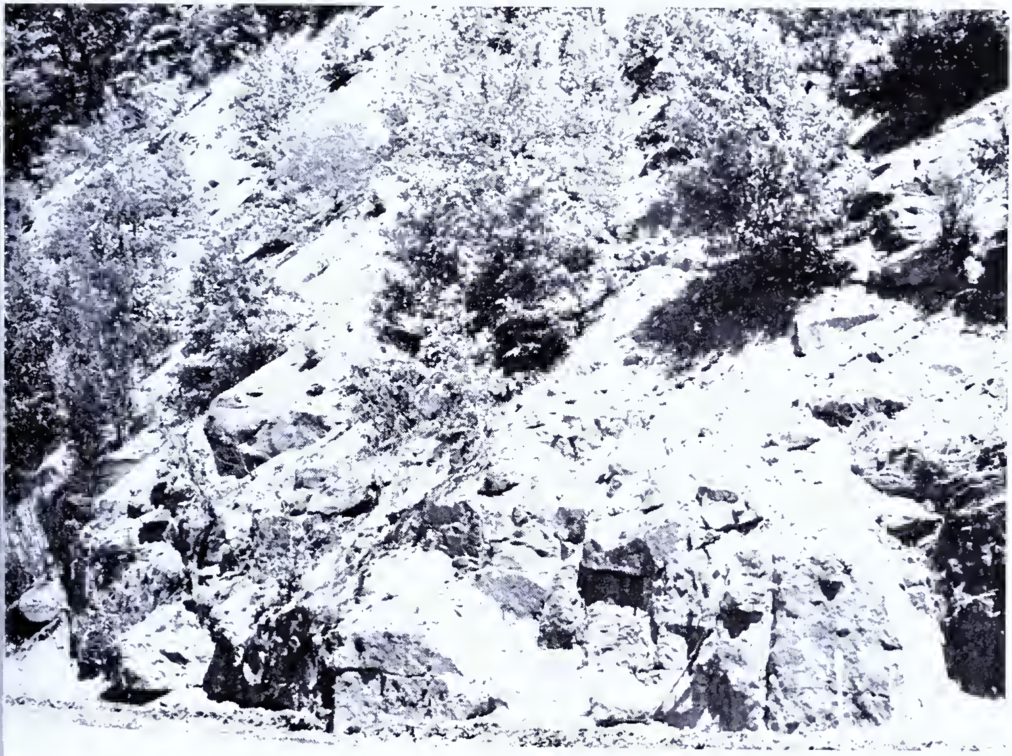


Figure 7. Massive sandstones of the Connoquenessing Formation exposed along the Turnpike (Ab 16).

a persistent sandstone which averages 30 feet in thickness and is assigned to the Homewood Formation. Locally the sandstone grades, in part, to siltstone or shale.

No precise upper and lower limits have been assigned to these formations in the Donegal area, because a lack of exposures prevents a detailed knowledge of their character and variations. The geologic map (Plate 1) shows that rocks of the Pottsville Group crop out over a large irregularly shaped area on Laurel Hill and Chestnut Ridge.

Allegheny Group

The Allegheny Group was called the "Lower Productive Coal Measures" by the early geologists because it contained valuable coal beds. Rogers (Rogers, H. D., 1858) gave the group its present name for exposures of these rocks along the Allegheny River north of Pittsburgh. The limits of the Allegheny Group extend from the base of the underclay of the Brookville coal to the top of the Upper Freeport coal.

Rocks of the Allegheny Group occur as irregular bands on the foothills of Laurel Hill and Chestnut Ridge. They also crop out in the stream valleys in the Ligonier syncline in the southwestern part of the quadrangle. A complete section of Allegheny rocks is nowhere exposed in the Donegal quadrangle. Sections compiled from partial exposures measured at various places show an overall average thickness of 230 feet.

Graphic sections constructed from the records of core drill holes in the southwestern part of the Ligonier syncline are shown on Plate 2. These sections illustrate the characteristic repetition of depositional sequences in the Allegheny Group. Other characteristics of the Allegheny such as lateral gradation from coarse to fine sediments and channel-fill sandstones are also illustrated in the sections.

The Allegheny Group is noted for its important coal beds. In the Donegal quadrangle, the lower Kittanning coal is persistantly minable in large areas and has undergone large scale commercial development.

Variable quantities of plastic clay underly the coal beds, but they are not known to have been tested. Fresh-water limestones are present below the underlay of some of the coal beds. These limestones are megascopically indistinguishable from one another. They are bluish-gray, hard, compact and have a subconchoidal fracture. The joints and bedding planes have been enlarged by solution in the zone of weathering, forming limestone boulders at the outcrop. Minute, unidentified fossils, thought to be brackish water forms, are present in some of the limestones.

Sandstones in the Allegheny are generally irregularly bedded, cross-laminated lenticular beds of sand which are usually unconformable at the base. The colors of the sandstones are various shades of gray and iron-stained brown. Mica flakes, scattered or abundant, iron concretions, irregular lenses of carbonized material and fragments of fossil plants are present in the sandstones occasionally (Plate 2). Sandstone is the dominant material in the Allegheny section. Sandstones in the upper part of the Allegheny tend to be fine-to-medium bedded and local in occurrence, whereas sandstones in the lower part of the group tend to be more widely distributed, coarse-grained, locally massive with conglomerate lenses, and less easily disintegrated; locally they are physically similiar to Pottsville sandstones and may easily be mistaken for them.

In some localities (Plate 2) the Allegheny Group is almost entirely composed of siltstones and shales. These are gray, greenish gray, or buff in color. The roof shales of the coal beds are commonly carbonaceous and usually contain scattered siderite concretions.

The Allegheny Group is divisible into three formations named from base to top, the Clarion, Kittanning, and Freeport Formations. The formations are of mappable thickness and are recognizable, but because of poor exposures in the area, map scale, and limited traceability of marker units, the formations have not been differentiated on the geologic map (Plate 1). The reader is referred to the "Composite Columnar Section" in Plate 1 and also to Plate 2 for a visual characterization of the Allegheny section. The columnar section illustrates well the lack of lateral persistence of individual rock bodies in the section, including the coals. Lateral variation is especially marked in the sandstone-shale complexes between the coals. Underclays seem to be the most persistent units, being present, at times, even when their associated coal has disappeared. Because lateral variability exists, an abnormally large number of measurements are required in order that a given sequence of rocks may be adequately described. Exposures in the Donegal quadrangle are inadequate to allow definition of the variation of the sandstone-shale complexes, or even, in some cases, to allow definition of all of the lithologic types involved in the complex. For this reason, discussion of the column necessarily emphasizes the units which are best seen, i.e. those which are mined or exposed in mining and those which are resistant enough to form outcrops. Because sandstones are nearly the only units which persistently crop out, a tendency exists to overemphasize this lithology. The same tendency exists to overemphasize the importance stratigraphically and lithologically of the coals and the underclays, both because they are seen in mining and because they are economically valuable units. The proportionate importance of these beds is best shown in the columnar section (Plate 1).

Referring again to the columnar section in Plate 1, the Formations named above are defined as follows: The Clarion Formation includes the rock units between the base of the Brookville underclay and the base of the underclay beneath the lower Kittanning coal. The Kittanning Formation lies above the Clarion Formation and extends upward to the top of the upper Kittanning coal. The Freeport Formation included the sequence of rocks between the top of the upper Kittanning coal and the top of the upper Freeport coal, which horizon is also the top of the Allegheny Group.

For purposes of discussion, the column will be divided into these three formations even though the formations as such have not been mapped, because the rock units in the area can be fitted into this classification.

Clarion Formation

The Clarion Formation consists at the base of underclay overlain by coal. Above the coal is a section of dark carbonaceous somewhat fissile shales which contain numerous siderite concretions. The top of the section was seldom seen, but at one place appeared to be shale continuously to the top. Near the top, large concretions were observed, one of which was found to contain the brachiopod *spirifer opimus* hall. This brachiopod is a common fossil in the marine Vanport limestone which occurs in other parts of western Pennsylvania. The Vanport limestone as such was not seen in the Donegal area and has not been reported from other parts of Fayette and Westmoreland Counties. The zone of concretions, on the basis of the fossil content, is believed to represent the horizon of the Vanport.

Sand bodies, believed to be channel sands, are known to occur at some places in the area within the shales over the coal. Such sand bodies appear to be well developed near Fourmile Run west of Mansville. The underclay beneath the coal is a plastic clay, megascopically of good quality, and is known to reach a maximum thickness of 5 feet. Bands of bleached-white plastic clay at the surface serve to mark the outcrop of the coal. The coal is correlated with the Brookville coal of adjacent areas and with several jumps is correlated through the New Florence quadrangle and the Smicksburg quadrangle with the Brookville of the type section. Some doubt has been cast recently on the validity of the Brookville as a distinct, separate coal from the Clarion, the contention being made that Brookville may be the same coal as part or all of the Clarion at the type section.

For this reason, the legend of the geologic map (Plate 1) shows Clarion as an alternate interpretation for this coal. No other coal occurs in the Clarion Formation in the Donegal area. The Brookville coal has an average thickness of 3 feet in the area where it has been mined north of Jacobs Creek on Chestnut Ridge. It appears to be of fair quality. Based largely on the well records shown in Plate 2, the Clarion Formation averages about 40 feet thick.

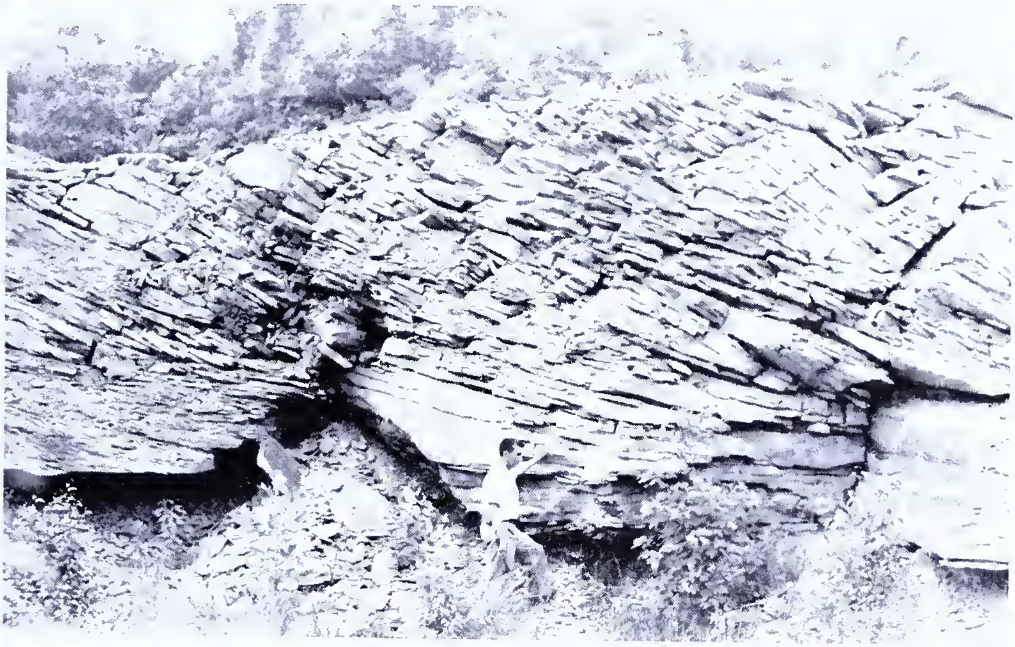


Figure 8. Crossbedded Worthington sandstone as exposed in a strip mine on the lower Kittanning coal southeast of St. Boniface Chapel (Ba 23).

Kittanning Formation

The Kittanning Formation varies in thickness from about 100 to 130 feet. It contains three named coals, the lower, middle, and upper Kittanning coals. The upper Kittanning coal bed, as shown in Plate 2, is not persistent and is consequently not a good marker bed for the top of the formation in this area. The formation includes from base to top the Lower Kittanning coal and its associated underclay. The underclay is plastic, apparently of good quality, and varies in thickness from 3 to 5 feet. The Lower Kittanning coal is the most persistent coal in the area, and, next to the Pittsburgh coal, is the most mined coal in the area. Thickness of the coal is persistently between 28 and 42 inches, averaging about 3 feet.

Above the lower Kittanning coal is a shale-siltstone complex which includes sandstones whose position in the section is variable. The sandstone in this part of the section was named the Worthington by Platt (1800), the name being applied to a coarse-grained and pebbly sandstone 40 feet thick occurring above the lower Kittanning coal at the town of Worthington in Armstrong County, Pennsylvania. Flint (1956) applied the name in Somerset County for sandstones between the upper and lower Kittanning coals. The sandstone bodies between the lower and middle Kittanning coals are here called lower Worthington; between the middle and upper Kittanning coals, the sands are called upper Worthington.

The lower Worthington sandstones persistently crop out on the west limb of Laurel Hill from Weaver School southwestward to near Jones Mill. Lenticular beds of sandstone are in the highwalls of strip mines on the lower Kittanning coal in the southwestern part of the quadrangle. In the same area, the upper Worthington sandstone is generally massive and caps the hilltops. Massive sandstones that are locally conglomerate occur at the lower Worthington horizon above the lower Kittanning coal in the higher knobs of Chestnut Ridge.

In the upper part of the section above the lower Kittanning coal, an argillaceous limestone is commonly seen which averages about 5 feet in thickness; its top is normally about 10 feet below the base of the middle Kittanning coal. Locally the limestone is cut out by channel sandstones, but otherwise it appears to be persistent. It is in the position of the middle Kittanning limestone of adjacent areas. Shales, siltstones or sandstones are present normally between the limestone and the underclay beneath the middle Kittanning coal. The underclay is a plastic clay ranging in thickness from 0 to about 4 feet. The middle Kittanning coal occurs about 60 feet above the lower Kittanning coal. Its occurrence is erratic in that it thickens, and thins, locally splits, and is occasionally cut out by sandstone (Plate 2). The thicker beds contain at least one shale parting and numerous lenses of sulphur. The coal was strip-mined extensively in southwestern Saltlick and northwestern Springfield Townships (Ac 20, 29, 32, 45). Middle Kittanning members as well as units between the middle and upper Kittanning coals are exposed in the highwall of a strip mine on the lower coal west of Rasler Run (Ac 47). At that locality, the middle Kittanning limestone contains minute gastropods which are megascopically visible on weathered surfaces.

The section above the middle Kittanning coal is unkown except for information contained in the core drill sections presented in Plate 2. Plate 2 indicates that the section is highly variable and includes shales, siltstones, sandstones and a limestone which appears to be local. A small rider coal is present in some sections above the middle Kittanning coal. The upper Kittanning coal and its associated limestone are also local deposits in the area sampled by core drilling. The coal was exposed at only one place in the quadrangle where it was strip-mined in a small operation at Rodney (Bb 2). At this locality the bed averages 6 feet thick but is of inferior quality. The coal was at one time strip-mined near Acme (Ab 21), but the cuts are now backfilled so that no view of the coal in this area is possible.

The limestone beneath the coal is in the position of the upper Kittanning limestone (also called the Johnstown cement rock) of nearby areas. This limestone was worked in a small operation near Weaver Mill (Cb 2), but the pit is now filled. Flint clay exists in the section as indicated by scattered fragments found in test pits east of Jones Mills (Bb 23) and east of Roaring Run (Bc 7). This flint clay occupies a position approximately similar to that occupied by the 12-foot bed of flint clay in core-drilling section no. 5 on Plate 2. In the core-drill section the flint clay is overlain by 15 feet of alternating beds of clay and limestone occurring about 100 feet above the lower Kittanning coal and tenatively identified as the Johnstown cement rock.

As is apparent from the drill records in Plate 2, the problem of placing the top of the Kittanning Formation in this area is no small one. Nor can correlations of the various coals in this part of the section be made with certainty. Drill records, depending upon their source, are frequently questionable. If sufficient exposures were available in strip pits, or in outcrop, it may be likely that the horizon of the upper Kittanning coal could be traced even though the coal itself was discontinuous. In the drill records in Plate 2, it is not possible to define this horizon when the coal is absent. Since the definition of the top of the formation must be placed on the basis of the core-drill sections, the top can be defined only as occurring somewhere between the limestone above the middle Kittanning coal and below the lower Freeport coal.

The interval between the upper Kittanning coal and the lower Freeport underclay consists of shaly and silty beds with only minor amounts of sandstone. The Freeport sandstone, which in other areas is well developed in this interval, is not at all well developed in the Donegal quadrangle. From what records are available, the interval between these two coals would appear to range between 20 and 30 feet.

Freeport Formation

Information on the lower Freeport coal and associated beds is based upon the core drill records in Plate 2 and from scattered exposures in strip and test pits and outcrops. The coal is of mineable thickness in some localities on the west limb of Chestnut Ridge (see "Mineral Resources"). The coal is never seen without a shale parting and locally contains more than one parting of shale or bone. Underclay is usually present beneath the coal and is of variable thickness in some cases exceeding ten feet, as shown by the core drill records in Plate 2. Limestone locally occurs beneath the underclay. The interval between the lower and upper Freeport coals is usually occupied by shales and siltstones, but sandstones are locally present which probably represent channel fillings. These sand bodies are in the position of the Butler sandstone (White, 1878a). The sandstone is rather extensive in the upland around Buchanan in Saltlick Township, where it is massive, resistant rock having an estimated thickness of about 10 feet. An excellent fresh exposure of the Butler sandstone is in the wall of a strip mine on the lower Freeport coal on the west limb of Chestnut Ridge north of Jacobs Creek (Ab 12). There it is a gray, slabby to thick-bedded, medium-grained sandstone about 20 feet thick. Some beds are carbonaceous with abundant fragmental plant remains; iron stains on joints and bedding planes are common. The

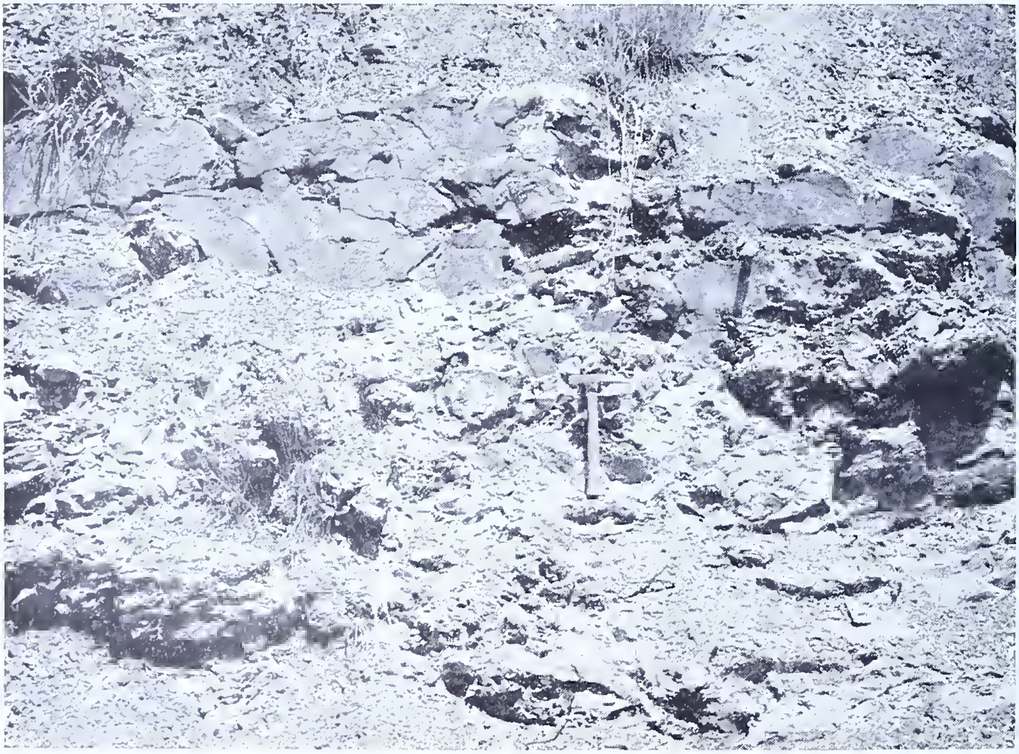


Figure 9. The Bolivar flint clay as exposed along the Turnpike (Cb 8).

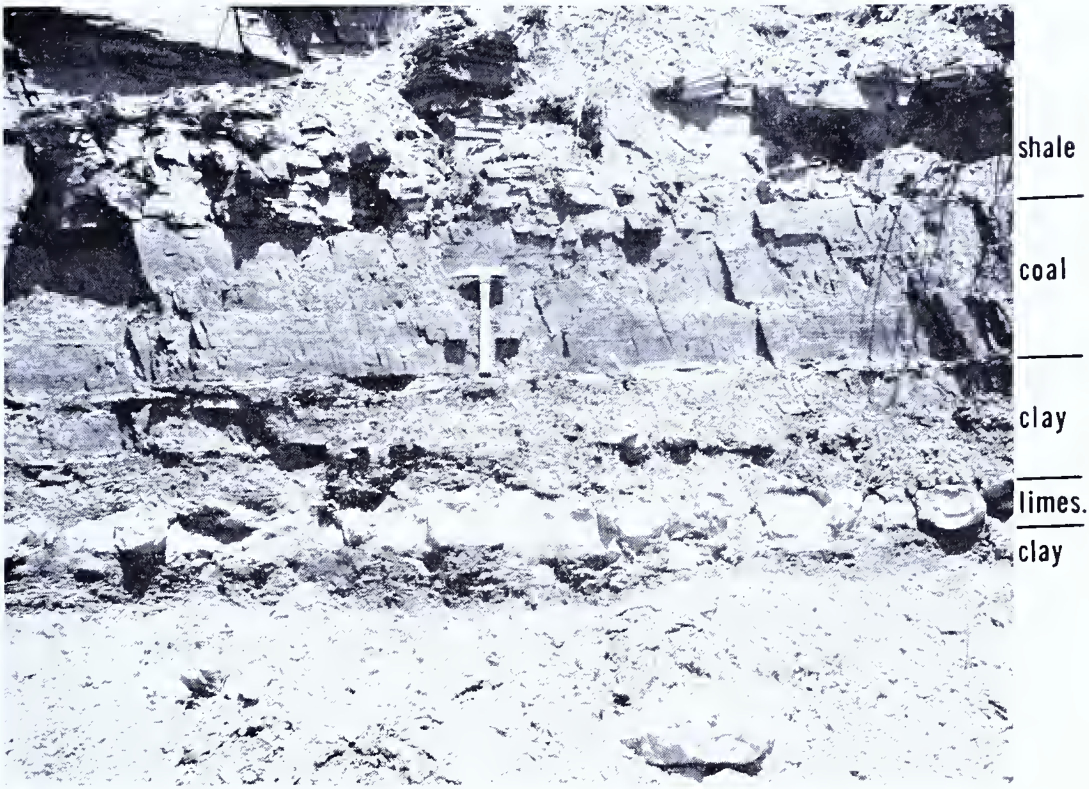


Figure 10. An expasure of the upper Freeport coal, clay, and limestone along the Turnpike (Cb 8).

base of the sandstone lies unconformably on the unevenly eroded roof shales of the coal.

Clay and limestone below the upper Freeport coal make up the top of the section between the two coals. Neither the clay nor the limestone are persistant in the area. Exposures of these may be seen in Loyalhanna Creek (Ca 20), north of Bethal Church (Ba 19), along Fourmile Run (Ba 34), west of Packer School (Bb 3), west of Donegal (Bb 13), and the Pennsylvania Turnpike northeast of Franklin (Cb 8). Underclay beneath the upper Freeport coal was observed wherever the coal was seen. It appears to be a good quality, plastic clay varying in thickness from 0 to 6 feet. Limestone (upper Freeport) commonly occurs beneath the underclay. It is from 0 to 5 feet thick. Locally beneath the limestone, a bed of flint clay is found which is correlated with the Bolivar flint clay named after the type locality along the Conemaugh River in Westmoreland County (Stevenson, J. J., 1878). This flint clay is exposed along the Turnpike northeast of Franklin (Cb 8) where it consists of 4 feet of hard, brittle, semiflint clay containing lenses of siltstone. The areal extent of this clay is not known in the Donegal quadrangle, but the upper Freeport coal horizon was located at some places by weathered-out, angular fragments of semiflint clay.

The upper Freeport coal, which marks the top of the Freeport Formation as well as the top of the Allegheny Group, was observed at a number of places. Detailed sections of the bed are presented in the section on "Mineral Resources." The coal is not persistent as shown in Plate 2 where it appears to be cut out by channel sandstones. The coal where observed varies in thickness from 10 inches to 34 inches and contains persistent partings which at times become thickened sufficiently to create a problem in mining. The coal has not been exploited commercially but has been worked in some places for local fuel.

Conemaugh Formation

General Description

The Conemaugh Formation was named for exposures of these rocks along the Conemaugh River in Indiana and Westmoreland Counties. The Formation extends from the top of the underlying Upper Freeport coal horizon upward to the base of the Pittsburgh coal, and it consists of alternating sequences of shales and sandstones with thin coal beds, limestones, and clay deposits occurring at approximately regular intervals in the section. The upper and lower parts of the Conemaugh are predominantly shales and siltstones, whereas the middle part consists chiefly of sandstones.

The Conemaugh Formation is distinguished from the underlying Allegheny Group by a series of red beds that occur at irregular intervals in the section and are accompanied locally by thin, impure limestones. The red beds consist of brick-red clay shales and/or purplish-red silty shales, and they commonly have greenish-gray fissile shale and crumbly clay associated with them. The thickness of these beds are from about 4 to 15 feet thick.

The Conemaugh also contains the Brush Creek and the Ames limestones which serve as excellent horizon markers beds because of their abundant fossil content and distinctive lithologies.

The Conemaugh Formation has not been formally subdivided in the past into a continuous succession of discrete member units. Instead, distinctive lithologic bodies have been separated out of the section and have been named and designated as members. A list of the named members of the Conemaugh does not serve to name all of the Conemaugh section, because indistinct lithologies have not always been given a name. Units have been named on the basis that a given recognizable lithology exists; little attempt has been made in many cases to place precise limits to the top or bottom of the named members. The significance of this may be seen by referring to the composite stratigraphic section on Plate 1. Shales and minor sandstone bodies, by and large, are not included within most of the names given alongside of the section. In addition, little attempt has been made to take into account the existence of lateral variation. Many of the named units are discontinuous. In intervals where a named unit disappears, no substitute name has been proposed for the beds equivalent to the named unit.

Though the Conemaugh rocks in this quadrangle underlie large areas of the surface, they are seldom well exposed. No attempt has been made on the geologic map (Plate 1) to subdivide the Conemaugh section. Although the need is recognized to establish a more concrete and realistic system of subdividing and naming the various lithologic bodies of the Conemaugh Formation, it was recognized early during field mapping that the exposures contained in the Donegal quadrangle were inadequate for this purpose. Mapping was consequently carried on using the earlier established method of defining the named lithologic units. Discussion of the section is likewise based upon the named units. The reader is referred to the composite stratigraphic section for an estimation of the predominate lithologies in the section between named units.

Named rock units or "members" of the Conemaugh which are recognized within the quadrangle are as follows:

Upper Pittsburgh: limestone
Connellsville: upper sandstone
Lower Pittsburgh: limestone
Connellsville: lower sandstone
Franklin: coal horizon, limestone and red beds
Upper Clarksburg: coal horizon, limestone and red beds
Morgantown: sandstone
Wellersburg: coal
Grafton: sandstone
Ames: limestone
Harlem: coal
Pittsburgh: red beds
Saltsburg: sandstone
Upper Bakerstown: coal
Woods Run: limestone and red beds
Lower Bakerstown: clay
Myersdale: red beds
Buffalo: sandstone
Brush Creek: limestone
Brush Creek: coal
Mahoning: coal, clay, and limestone
Mahoning: sandstone

The Conemaugh Formation crops out extensively in the Donegal quadrangle. It surfaces an area from about 4 to 5 miles wide in the Ligonier syncline in Westmoreland County and covers the uplands in the syncline in Fayette County. The thickness of the Conemaugh in the Ligonier syncline in the northeastern part of the quadrangle is estimated to be 750 feet. An irregular band of Conemaugh rocks from about .8 of a mile to 2 miles wide extends across the east limb of the Latrobe syncline in the northwestern part of the quadrangle. The estimated thickness of the formation in this area is about 650 feet.

Mahoning Members

The name Mahoning was originally applied to a sandstone overlying the roof shale of the Upper Freeport coal (Rogers, 1858). The name was later used to include the localized deposits of coal, clay, and limestone occurring about 50 feet above the Upper Freeport coal.

The only known exposure of the lower part of the Conemaugh Formation in the Donegal quadrangle is in the Mt. Joy cut on the Turnpike (Ab 5). At the east end of the cut, the Upper Freeport coal, 4 feet thick is overlain by 15 feet of gray shale which in turn is overlain by 20 feet of platy to flaggy, gray Mahoning sandstone, dipping northwest. About 100 feet farther west the sandstone fills a channel cut through the shale and into the coal. The Mahoning limestone horizon, occurring about 50 feet above the Upper Freeport, is marked by limonite nodules at the base of alternating pale-red and light-green shales 10 feet thick. The Mahoning coal, which occurs above the limestone is missing in this section.

The sections of core drill holes on Plate 2 that show the Mahoning interval, indicate local deposits of coal, clay, limestone, and sandstone.

Brush Creek limestone and coal

White (1878a) was the first to describe the Brush Creek limestone and coal from the type locality on Brush Creek in Butler County. These beds have a remarkably wide distribution in southwestern Pennsylvania, and are important stratigraphic markers.

The limestone which occurs about 100 feet above the Upper Freeport coal in the Donegal quadrangle, is dark gray, impure, abundantly fossiliferous, and has an observed maximum thickness of 14 inches north of Jones Mills (Bb 21) where it is enclosed in carbonaceous shales that are partly fissile, silty, and sparingly micaceous.

The weathering of the limestone often results in an iron-stained, silty, compact residual clay a few inches thick, enclosed in carbonaceous shale, which contains fossil impressions as can be seen south of Bethel Church (Ba 26). The Brush Creek limestone and associated beds appear in sections 9 and 12 on Plate 2.

The fossils in the Brush Creek limestone have not been identified in this area. Raymond (1908-1910) gives a list of fossils in the Brush Creek limestone from a few localities in southwestern Pennsylvania where the fauna is characterized by abundance of *Chonetes vernevilanus C*, *Bulimorpha nitidula C*, *Lophophyllum profundum C*, and *Griffithides sangamonensis.*

The Brush Creek coal which occurs about 10 feet below the limestone is separated from it by carbonaceous shale. The coal is exposed in the Mt. Joy cut on the Turnpike (Ab 4) where it is 7 inches thick and is underlain by gray clay of undetermined thickness. The horizon of the limestone is concealed in the cut. The Brush Creek coal was not seen elsewhere in the quadrangle, and it is missing in sections 7, 8, 9, 12 on Plate 2.

Buffalo sandstone

The Buffalo sandstone at its type locality on Buffalo Creek in Butler County (White, 1878a) is a massive, conglomerate sandstone occurring above the Brush Creek limestone. In the Donegal quadrangle, an incomplete exposure of the Buffalo sandstone north of Donegal (Bb 8) shows about 5 feet of greenish-gray, thinly laminated beds of siltstone and sandstone.

Meyersdale red bed and Pine Creek limestone

The Meyersdale red bed was named by Swartz (Swartz, C. K., 1922) for an excellent exposure in a cut on the Western Maryland Railroad east of Meyersdale in Somerset County. This member appears frequently in the geologic literature of Western Pennsylvania, northern Maryland, and West Virginia; it therefore appears to have a wide regional distribution.

The Meyersdale member occurs above the Buffalo sandstone and consists of approximately equal amounts of purplish-red, greenish-gray, or olive shale and greenish crumbly clay; the shale is fissile in part. The estimated maximum thickness is 10 feet. This member is apparently persistent in the Donegal quadrangle and lies about 150 feet above the Upper Freeport coal. It is a useful horizon marker where other key horizons are concealed. Fair exposures of the Meyersdale member are at the following selected localities: Northeast of Ridge School (Ca 2), north of Weaver Mill (Ca 21), south of Bethel Church (Ba 25), north of Jones Mills (Bb 20) and north of Donegal (Bb 6).

Lower Bakerstown coal and clay

This coal was originally described in the Allegheny River valley (White, 1877) where it has been mined in small operations despite its generally thin character. Geologic reports dealing with the Conemaugh Formation in southwestern Pennsylvania indicate that this coal is present, although it is possible that the Upper Bakerstown coal which lies about 50 feet above the Lower Bakerstown may have been mistaken for it in some areas.

The Lower Bakerstown can be traced in the Donegal quadrangle by weak coal blossoms and bleached-white plastic under clay. The horizon lies about 30 feet above the Meyersdale red bed and about 180 feet above the Upper Freeport coal. The Lower Bakerstown coal as exposed in a cut along Pa. Route 711 north of Donegal (Bb 7) measures 18 inches in thickness and is overlain by 10 feet of carbonaceous shale. A bleached-white plastic clay of undetermined thickness is under the coal. This coal is also exposed on the Turnpike at the Donegal interchange.

Woods Run limestone, (Raymond, 1911) and red beds, and the Upper Bakerstown coal occupy a position about 240 feet above the Upper Freeport coal horizon and lie immediately below the Saltsburg sandstone. A good exposure of the Woods Run limestone and associated members occurs on the north side of the Turnpike east of Donegal (Bb 10) where the following section was obtained:

Section on Turnpike east of Donegal (Bb 10)

Concealed	*Feet*	*Inches*
Red shale	5	0
Sandstone	3-4	0
Red shale	1	1
Limestone nodules in green shale	1	4
Limestone, bluish-gray, Woods Run	1	6
Thickness of section	12	10

About 100 feet east from the above locality another exposure shows the Upper Bakerstown coal and underclay. The red shale apparently has been eroded by channel scour and the latter subsequently filled with sand. A log of the section follows:

Section on the Turnpike east of Donegal

	Feet	*Inches*
Shale, carbonaceous, fissile	3+	
Coal, Upper Bakerstown	0	7
Clay, dark-gray, silty	0	6
Clay, gray, silty	10	0
Sandstone, light-gray, interbedded shale	14	0
Limestone, bluish-gray, Woods Run	1	10
Thickness of section	29	11

The Woods Run limestone was worked in a small operation east of Weltytown (Aa 21) for agricultural lime. The pit was filled with soil and red clay.

The red beds associated with the Woods Run limestone can be distinguished from the Meyersdale red beds by their darker and brighter shade of red, and, because they are less silty, they weather to a structureless mass of red clay. White plastic clay is present under the red clay locally.

Marine fossils have been reported in the Woods Run limestone from the type locality along Woods Run in Allegheny County (Raymond, 1911) and in Fayette County (Hickok and Moyer, 1940). No fossils were observed in the Woods Run limestone in the Donegal quadrangle.

Saltsburg sandstone

The geologic reports dealing with the Conemaugh Formation in southwestern Pennsylvania indicate that the Saltsburg sandstone is a prominent, wide-spread member. The unit was named by Stevenson (1878) for fine exposures along the Conemaugh and Loyalhanna Rivers near Saltsburg in Indiana County where it is 25 to 40 feet thick.

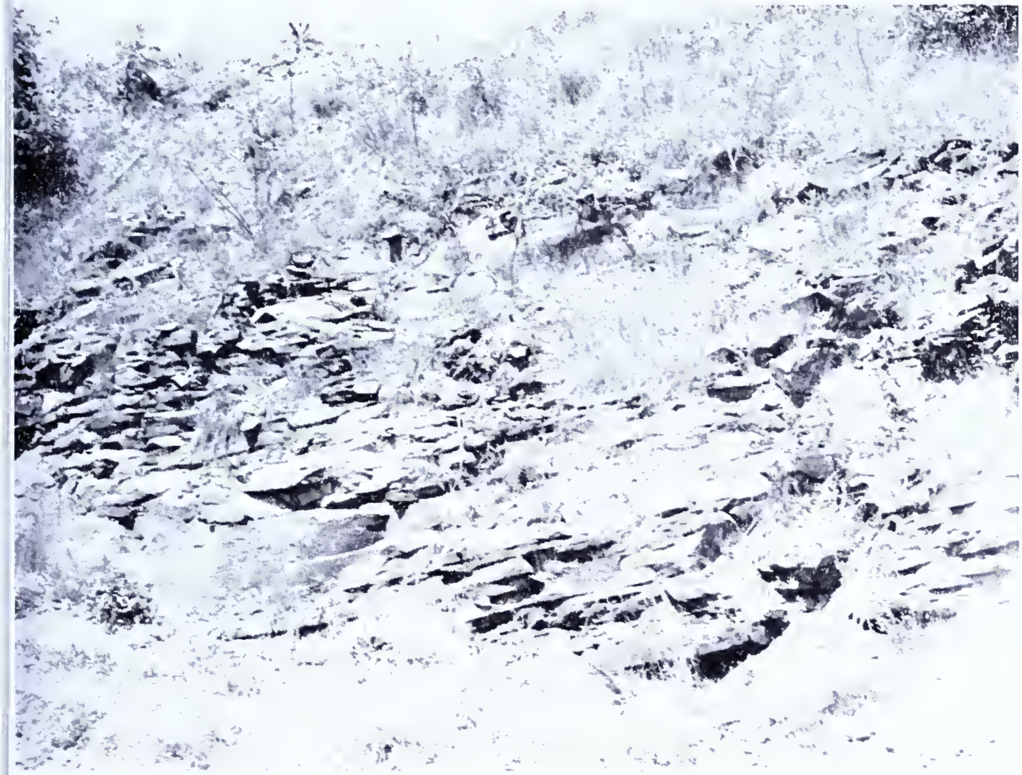


Figure 11. Saltsburg sandstone in a cut along the Turnpike (Ab 3).

Although the Saltsburg sandstone persists in the Donegal quadrangle, good exposures occur only locally. The maximum thickness of the deposit is about 30 feet, and the base, which is about 250 feet above the Upper Freeport coal horizon, lies unconformably on a bed of megascopically good quality light-colored plastic clay that is up to about 7 feet thick.

The weathered sandstone is various shades of gray; but weathered surfaces are commonly iron-stained. Grain size ranges from fine to coarse with scattered, opaque, pea-sized quartz pebbles in local lenses, particularly in the lower part of the deposit. Bedding varies from thin to massive with regular or irregular laminations. Where the rock is well cemented it resists weathering to form cliffs. By contrast, where cementation is weak, the rock becomes friable and weathers more rapidly. Forest cover prevails in the upland underlain by Saltsburg sandstone because the shallow, boulder-strewn soils are not favorable for agricultural purposes.

The Saltsburg sandstone forms the approximately flat upland on which the village of Donegal is situated; the uplands north and south of Donegal are also underlain by the Saltsburg. Outcrop of this sandstone occurs on Pa. Route 31 (Bb 11) south of Donegal. Massive conglomerate Saltsburg crops out in a cliff north of Jefferson School (Ca 5). Another fine exposure of Saltsburg occurs in the Mt. Joy cut on the Turnpike north of Laurelville (Ab 3) where the sandstone is 30 feet thick, light to dark gray, and consists of thin to medium beds with relatively thin partings of dark-gray, silty, micaceous shale containing fragmental fossil plant impressions.

Pittsburgh red beds

The Pittsburgh red beds lie immediately above the Saltsburg sandstone and were named for exposures along the grade lines of many railroads at Pittsburgh. This member in the Donegal quadrangle is indicated by a weathered exposure of red and green-gray shale on the east side of Fourmile Run just west of locality (Ca 8).

Harlem coal

The Harlem coal was named for that place in Carol County, Ohio, where it was mined extensively. It has a workable thickness in some localities in western Pennsylvania (Hickok and Moyer, 1940). Presence of the Harlem coal in the Donegal quadrangle is indicated by a blossom lying about 20 feet above the Pittsburgh red beds at the locality mentioned above (Ca 8). The coal had been prospected on the nearby steep hillside.

Ames limestone

The Ames limestone (formerly called the "crinoidal limestone"), occurs near the middle of the Conemaugh Formation, and is the highest known marine bed in the Pennsylvanian. Its consistent lithology is southwestern Pennsylvania, eastern Ohio, and northern West Virginia, makes it an exceedingly useful marker horizon. The type locality is at Amesville in Athens County, Ohio, for which it was named by Andrews (1873).

The identity of this limestone is unmistakable for it has a distinct green-grey color; it is commonly overlain by red shale and contains an abundant marine fauna. Raymond (1911) reports the following species in the Ames limestone from a locality one-quarter mile west of Blairsville intersection in Westmoreland County; *Chonetes granulifer C, Ambocoelia planaconvexa C,* and *Derbya crassa C.*

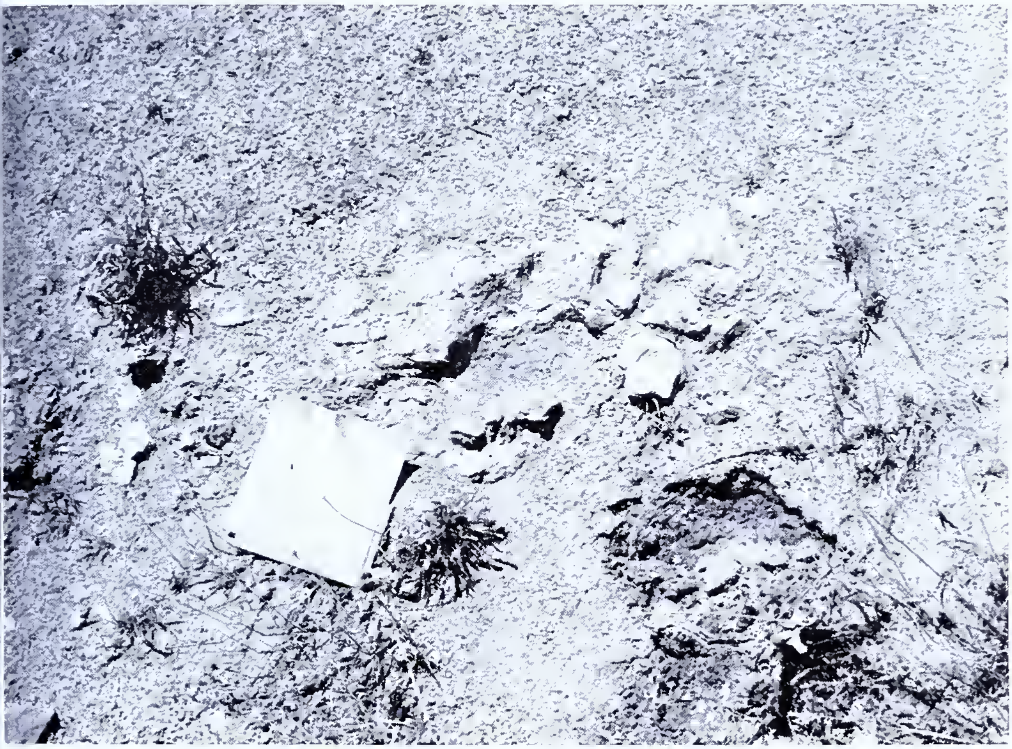


Figure 12. A typical exposure of the Ames limestone. Crops of the Ames are seldom found because the limestone decomposes rapidly under weathering. In a little more than 20 years, this newly exposed crop of Ames has weathered to nodules in a clay mass.

The Ames limestone in the Donegal quadrangle occupies a position approximately 330 feet above the Upper Freeport coal horizon. The best exposure of the Ames limestone in the area is on the north side of the Turnpike in the Mt. Joy cut (Ab 2) where it is 18 inches thick and very fossiliferous. Outcrops of the Ames limestone also occur along Fourmile Run (Ca 14, 15).

Grafton and Morgantown sandstones

About 15 feet above the Ames limestone in the Mt. Joy cut on the Turnpike a 20-inch-thick coal is found, underlain by 6 feet of clay containing limestone nodules (Ab 1). The correlation of these units is uncertain. Immediately above the coal bed is a series of medium to thick-bedded, medium-grained sandstone with local cross laminations. The thickness of the section is 97 feet which is also the depth of the vertical walls in the cut. The sandstones in the lower half of the cut correlate with the stratigraphic position of the Grafton as described elsewhere (Stevenson, 1876), and the sandstones in the upper half of the cut correspond to the stratigraphic position of the Morgantown which was named by Stevenson (1876) for outcrops near Morgantown, West Virginia.

Fair exposures of the Grafton and Morgantown sandstones occur at the east side of Fourmile Run (Ca 8, 9) where a section, a little over 100 feet thick, shows a series of gray and green-gray, medium to massive, fine to coarse-grained sandstone beds parted by lesser beds of gray and green-gray shales.

The Grafton and Morgantown sandstones underlie the uplands in the central part of the Ligonier syncline from Stahlstown northeastward. The local resistant character of some of these sandstone beds is evidenced by massive boulders.

Wellersburg coal

A thin coal blossom overlain by silty carbonaceous shale which contains fragmental plant impressions occurs in the Ligonier syncline in the northeastern part of the Donegal quadrangle (Ca 13). This horizon occupies a stratigraphic position similiar to that of the Wellersburg coal, which at the type locality at Wellersburg, Pennsylvania is underlain by limestone (Swartz, 1922). The Wellersburg, at present, is concealed in the Mt. Joy cut (Ab 1) and in the section east of Fourmile Run (Ca 8, 9).

Clarksburg members

The name Clarksburg was given by White (1891) to a coal bed with a limestone below, occurring in the upper part of the Conemaugh, and above the Morgantown sandstone near Clarksburg, West Virginia.

In the northeastern corner of the Donegal quadrangle, weathered outcrops of red beds with nodular limestones lying about 250 and 200 feet respectively below the Pittsburgh coal, and above the Morgantown sandstone were noted in the hillside south of Loyalhanna Creek. Exact locations could not be made. Weathered outcrops of red beds occupying approximately similiar stratigraphic positions occur in the Latrobe syncline south of Lycippus (Aa 20).

Blossoms of a coal bed, lying about 240 feet below the Pittsburgh coal and above the Morgantown sandstone were found in the Ligonier syncline east of Jefferson School (Ca 16) and west of Ligonier County Club (Ca 17). This coal is the probable correlative of the Clarksburg coal, 8 inches to 1 foot thick in Fayette County (Hickok and Moyer, 1940). The Clarksburg limestone had been worked many years ago on the hilltop east of Pleasant Grove (Ca 24).

Franklin coal and limestone

In the northeastern corner of the Donegal quadrangle, a coal blossom underlain by bluish-gray limestone nodules lies about 150 feet below the horizon of the Pittsburgh coal in a poor exposure on the hill south of Loyalhanna Creek (Ca 11). Stratigraphically, their position correlates with that of the Franklin coal and limestone as indicated in the generalized columnar section of southern Somerset County compiled by Flint (1956).

Connellsville sandstones

The Connellsville sandstone was named originally by Stevenson for excellent exposures of this rock along the Youghiogheny River south of Connellsville in Fayette County, where its top lies at an average position of 65 feet below the Pittsburgh coal, and it averages in thickness from 50 to 80 feet.

In the Ligonier syncline in the northeast corner of the Donegal quadrangle, two thinly laminated, fine-grained, green-gray, micaceous sandstones, each about 10 feet thick, occur at 115 and 75 feet respectively below the Pittsburgh coal. These units are here referred to as lower and upper Connellsville sandstones.

Lower and Upper Pittsburgh limestones

Rogers (1858) gave the name Pittsburgh to limestones occurring below the Pittsburgh coal bed. Two limestones occur at positions of about 100 and 45 feet respectively below the Pittsburgh coal in the northeast corner of the Donegal quadrangle. The lower limestone was worked in a small pit on a hilltop south of Loyalhanna Creek (Ca 12) but the pit has been filled with soil. The upper limestone was quarried and burned for field lime west of a small knob underlain by Pittsburgh coal (Ca 10). The limestone in the quarry is now concealed, but it was reported to be 4 feet thick.

Monongahela Formation

H. D. Rogers (1858), was the first to study these strata in the valley of the Monongahela River near Pittsburgh and he named them the Upper Productive Coal Measures. Stevenson (1873) called them the Upper Coal Group or Monongahela River Series. These rocks are limited at the top by the Waynesburg coal and at the base by the Pittsburgh coal. The Monongahela is considered to have only formational rank in this report.

The Monongahela Formation is similiar to the Allegheny Group below in that it consists of cyclic sequences of sandstones, shales, limestones, clays, and coals; it also contains economically minable coal beds.

Strata of the Monongahela Formation underlie the greater part of the Latrobe syncline in the northwestern part of the Donegal quadrangle, and at the western boundary of the quadrangle where all of it is preserved from erosion, is 380 feet thick. Because of the low topographic relief, and the relatively thick cover of soil, exposed outcrops of Monongahela rocks in the Latrobe syncline are very rare. In addition, subsurface data such as records of core drill holes and sections measured in sinking mine shafts were not available. Therefore, data were insufficient to compile a complete stratigraphic section of the Monongahela Formation. Brief descriptions of the previously named Monongahela members were obtained from partial exposures in the Latrobe syncline within the Donegal quadrangle and are set forth below. Detailed sections of the Monongahela have been measured and reported from Fayette County west of the Donegal quadrangle (Hickok and Moyer, 1940).

Pittsburgh coal

The Pittsburgh coal at the base of the Monogahela Formation is uniformly distributed over 8,240 acres in the Latrobe syncline within the quadrangle. The outcrop in the northwest corner of the quadrangle extends about 1.1 miles along Brinker Run. On the east side of the Latrobe syncline, the outcrop of the Pittsburgh coal follows an irregular line west of Brush Creek northeastward past Mammoth, Jacks School, and Ninemile Run. Economic large scale extraction of Pittsburgh coal was completed in this area in the second quarter of the century.

Very small remnants of the Pittsburgh coal are preserved in four knobs in the Ligonier syncline in the northeast corner of the Donegal quadrangle.

Redstone coal and limestone

The Redstone coal and limestone were named by Rogers (1858) for a locality on Redstone Creek, near Uniontown, Fayette County. These members are about 80 feet above the Pittsburgh coal in the Latrobe syncline. The Redstone coal was strip mined in a minor way north of Mutual (Aa 5), but exposures of the bed are now subsequently covered by falls of shale from the highwall. It is reportedly 3 to 4 feet thick and of inferior quality. The coal and underlying freshwater limestone are partially exposed in a cut on the Turnpike at the west boundary of the quadrangle (Aa 37)

Cleaves (1949) measured the section when it was exposed during construction of the Turnpike and reported the coal to be 66 inches thick and containing numerous binders. The coal is overlain by shale, and a limestone over 5 feet thick lies immediately below the coal.

Fishpot limestone

The Fishpot limestone was given its name by Stevenson (1876) for a locality on Fishpot Run in southern Washington County. This limestone is extensive in western Fayette County where it is a hard gray homogeneous rock which occurs in 1- to 3-foot beds (Hickok and Moyer, 1940).

The extent of the Fishpot limestone in the Latrobe syncline in the Donegal quadrangle is unknown, due to lack of exposures. The only exposure of the Fishpot was found northeast of Mutual (Aa 4) where it was worked in a small pit, which is now filled in. The limestone there lies about 115 feet above the Pittsburgh coal.

Sewickley coal

The Sewickley coal (Rogers, 1858) is reported from Fayette County (Hickok and Moyer, 1940) as a lower and an upper bed, the lower one having minable quality in certain localities. Sewickley coal is not known to have been tested in the Latrobe syncline in the Donegal quadrangle. Its horizon is indicated by weathered carbonaceous material occurring about 180 feet above the Pittsburgh coal at an outcrop .8 of a mile east of Pleasant Unity.

Benwood and Uniontown limestones

The interval from the top of the Sewickley coal horizon upward for about 115 feet contains a sequence of alternating beds of limestone, shale, and thin sandstones. The limestones are bluish gray, compact freshwater deposits. The Benwood limestone is included in the lower part and the Uniontown limestone is included in the upper part of this interval, but they cannot be distinguished. These limestones have been quarried in small operations at a few places (Aa 17, 18, 19) and burned for local agricultural lime.

The interval from the top of the Uniontown limestone to the base of the Waynesburg coal, a distance of 90 feet, normally includes the Uniontown coal and the Waynesburg limestone. In the Latrobe syncline in the Donegal quadrangle, however, this interval is concealed so that the presence of the Uniontown coal and the Waynesburg limestone is speculative.

Waynesburg coal

The Waynesburg coal bed (Rogers, 1858) which marks the top of the Monongahela Formation, is also the arbitrary Pennsylvanian boundary. It underlies about 22 acres in a hilltop in the Latrobe syncline at the western boundary of the Donegal quadrangle (Aa 33). The Waynesburg coal had been strip-mined in this locality. The bed is 5 feet 8 inches thick, but it contains relatively thick partings. Following is the section:

Section of Waynesburg coal (Aa 33)

	Feet	*Inches*
Shale, silty		
Coal, bony	0	2
Shale	0	9
Coal, bony	0	8
Coal	1	4
Shale	0	2½
Coal	1	½
Shale	0	1
Coal	1	5
Shale		
Thickness of bed:	5	8
Thickness of coal:	3	9½

Washington Formation

The Washington Formation has been eroded everywhere from the area with the exception of a very small remnant overlying the Waynesburg coal in Mount Pleasant Township along the western edge of the quadrangle. The rocks remaining have been identified as the Cassville shales.

Cassville shale

The name Cassville was given by White (1891) to a dark gray shale, prolific in fossil plants, that overlies the Waynesburg coal in the vicinity of Cassville, Monongahela County, West Virginia. This shale, the lowest member of the Washington formation, is Permo-Pennsylvanian in age.

About 30 feet of gray, silty shale overlies the Waynesburg coal where it was strip-mined at the western boundary of the Donegal quadrangle (Aa 33). This shale is presumably the Cassville which represents the basal part of the Washington formation. However, a cursory search for plant fossils was unproductive.

MINERAL RESOURCES

Coal is the most important mineral resource in the Donegal quadrangle. On the basis of the first reported coal production, mining on the Pittsburgh coal in the Latrobe syncline began in the last quarter of the nineteenth century and flourished continuously into the second quarter of the twentieth century when large scale mining became economically impractical. The original deposit of Pittsburgh coal in the quadrangle underlaid about eight thousand acreas and contained 114 million tons of coal.

Mining on the lower Kittanning coal bed in the Ligonier syncline in the area about Melcroft and Indian Head began about 1915 and became increasingly active, and at one time coal was being produced from eight large commercial mines in the area. Only one mine, the Melcroft no. 1 was operating in 1961.

Coal mining and the manufacture of coke supported the economy of the area for many years. But these are no longer the main support of the economy in this and numerous other former coal mining communities in Pennsylvania. Coal was a leading source of energy until about 1953 when the coal industry began to lose its most lucrative markets to the more convenient fuel oil and natural gas for heating. Utilities are the largest consumers of coal and, although the output of electric power is increasing, the efficiency of burning is continually being improved, thus requiring less coal per kilowatt-hour produced, (1.7 lbs. coal per K.W. hr. in 1920, 0.88 lbs. coal per K.W. hr. in 1960).

The coal industry has met the competitive fuels by reducing mining costs with the development of continuous mining machines and improved conveying and transportation equipment which greatly increased the tons-per-man output. But, by the same token, mechanized mining requiring fewer miners, has caused serious unemployment conditions in presently active coal mining communities.

When, through research in utilization, additional markets for bituminous coal have been created, reserves are available in almost limitless quantities. Although the Pittsburgh coal at the base of the Monongahela Formation has been exploited to its economic limit in the Donegal quadrangle, the Allegheny Formation underlies very great areas and contains reserves of coal that are qualitatively and quantitatively minable; they are of medium volatile bituminous rank and are classified as coking coals.

Plastic clays ("fire clay") commonly accompany the coal beds in the Pennsylvanian, particularly in the coals in the Allegheny Formation. Clay or clay products have not been produced in the area. Good quality plastic clays and minor semiflint clays are indicated at the outcrops and in core drill holes. Underclay has been uncovered in extensive coal strip mines, but it is not known to have been tested.

Sandstones suitable for various structural uses are everywhere available. The Loyalhanna limestone crops out extensively; it is quarried commercially on Laurel Hill and Chestnut Ridge. The Greenbrier limestone in the lower part of the Mauch Chunk Formation and the argillaceous limestones in the Allegheny Conemaugh and Monongahela Formations had been worked by farmers and burned for agricultural use. Commercially manufactured lime has replaced the laborious, primitive methods of obtaining lime. Shales occur in thick deposits, but their usefulness has not been tested. Lean iron ores occur as secondary oxides (limonite and hematite) and carbonate (siderite). These ores were "benched" and smelted in charcoal furnaces many years ago; they no longer have economic value.

Deep natural gas pools on Chestnut Ridge and Laurel Hill anticlines are recent discoveries. Great volumes of gas are produced from the Onondaga chert and Oriskany sandstone. Large potential gas areas remain to be explored. Production of natural gas has negligible effect on the local economy.

The ensuing discussions consider, in some detail, the character, quality and distribution of the mineral resources and appraises their present and future economic value. Mines, open pits, outcrops and the wells drilled for natural gas that are referred to in the text are shown by symbols on Plate 1. Coal beds are indicated by abbreviation of their names; they are identified in the explanation at the right side of the map. To facilitate reference between map and text, the rectangles formed by the 5-minute lines of latitude and longitude are taken as reference units. The vertical rows are designated by capital letters, and the horizontal rows by small letters. As an example, Bb 10 refers to a datum point in the second vertical row from the left and the second horizontal row from the top. All datum points are tabulated in Appendix II.

COAL

Origin And Character

For information on the origin and microscopic character of coal, the reader is referred to a recent publication by Koppe (1960). Essential information about coal of benefit to the producer and the consumer involves the megascopic impurities contained in the coal bed, the proximate analysis of the coal, determination of its rank and coking qualities, and the preparation characteristics of the coal. Terms used are defined in the glossary which accompanies this report.

Impurities In Coal

Coal beds are rarely free from impurities of some character such as shale, "slate", clay, and pyrite ("sulphur"). These partings and/or binders varying in number and in thickness range from a knife edge up to several feet in vertical extent. Some persist in thickness and position in the bed over a relatively wide area, whereas others are ocal lenses. Pyrite is particularly irregular and nonpersistent. It appears to have replaced fusain locally. Pyrite also occurs as disseminated fine particles. Clay dikes or squeezes intrude along vertical cracks or joints. They are wider and more numerous toward the outcrop where pressures have been released by erosion of thick overburden. Considerable coal thus affected has been encountered in strip mining near the outcrop.

Classification of Coals

To meet the needs of both scientific and commercial interests, coals have been classified according to their inherent properties and composition. 1. By rank, or according to the degree of metamorphism, or progressive alternation in the geological series from lignite to anthracite. 2. By grade, or according to quality as determined by calorific value, ash and sulphur content, ash-softening, size, etc. 3. By type or variety such as common banded, splint, cannel and boghead, or algal coals. The table showing the standard classification of coal by rank appears in the American Society for Testing Material Report of sectional committee D-5 on classification of coals, 1954.

On the basis of relatively few analyses obtainable of Pottsville and Allegheny coals in the Donegal Quadrangle, it appears that they are of medium volatile bituminous rank, or lie approximately within the following limits: Dry fixed carbon; 69 percent or more to less than 78 percent. (Dry volatile matter 31 percent of less to more than 22 percent). The coals in the area are the common banded type or are composed of alternating bands of bright (anthraxylon) and dull (attritus) coal.

Coking

Aside from the practically depleted reserves of Pittsburgh coal in the Latrobe syncline which was consumed almost entirely for manufacture of coke in beehive and by-product ovens, minable coals produced in the area are used largely for development of electric power with lesser amounts being used for fuel. Although their coking qualities are unknown, some of them probably would serve for that purpose, though they may require preparation and blending.

The U. S. Bureau of Mines (1951) has published reports on the preparation characteristics of coals in Fayette (R. I. 4815) and Westmoreland (R. I. 4823) Counties.

Analyses of Coal

Available analyses of coals in the Donegal quadrangle are assembled in the accompanying table. Table no. 1 shows proximate analyses for various coal beds made from mine samples and from

Table 1. Proximate analyses of coal beds

Coal bed, map location		Volatile matter	Fixed carbon	Ash	Sulphur	Phosphorus	Fusion temperature °F
Middle Kittanning	Ac 15	27.3	63.9	8.8	2.8	0.02	
do.	Ac 24	25.5	64.0	10.5	1.9	0.02	
Lower Kittanning	Ab 34	27.8	63.0	9.2	1.4	0.06	
do.	Bb 24	23.7	67.3	9.2	1.8		2495
do.	Bc 2	23.2	66.6	10.2	2.15		2550
do.	Bc 3	26.2	63.1	10.7	3.8		2275
do.	Bc 5	25.0	63.8	11.2	3.8		2295
do.	Bc 4	26.0	65.1	8.9	0.8	0.07	
Brookville	Ac 31	26.3	58.6	15.1	4.1	0.03	

cores recovered from diamond drill holes. The analyses shown in the Tables no. 2 and no. 3 were made by U. S. Bureau of Mines (Technical Paper 590). Table no. 2 gives proximate analyses of coal as shipped and delivered, i.e., as received by purchasers and consumers. Samples are taken after the coal is mined and has received customary cleaning. The samples are collected according to the American standard method (Pope, 1917). Table no. 3 shows proximate and ultimate analyses of mine samples which represent the coal in place and are intended for use by mine operators. The samples are collected according to the standard method adopted by the U. S. Bureau of Mines and the Geological Survey (Holmes, 1918). A mine sample contains the best quality of coal that can be produced, because the samples exclude impurities in the bed and those arising from roof and floor conditions. An average or composite analysis of a number of face samples will show a lower percentage of ash than the analyses of run-of-mine coal from the same mine; the reason being that the miner is primarily interested in producing large tonnages and might become careless in excluding impurities. For details on sampling methods, chemical analysis, and methods of testing and reporting, the reader is referred to American Society for Testing Materials—standards on coal and coke, 1959.

Sources of Coal Information

Most of the information about the coal beds in the Donegal quadrangle was obtained by the author from deep mines, strip mines, test pits, outcrops and records of core drill holes. Indirect information such as oral reports from residents as to the thickness and character of a coal bed where it had been opened but is now concealed were used advisedly. Previously published sections of coal beds in Bullkin,

Table 2. Analyses of run-of-mine coal—delivered and tipple samples

U. S. Bureau of Mines

Mine and coal bed	Air-drying loss	As received moisture	Volatile matter	Fixed carbon	Ash	Sulphur	British Thermal Units	Calories	Soften-ing tempera-ture °F	Approxi-mate tons delivered	Number of analyses averaged	Bureau of Mines analysis number	Sampled at
Lower Kittanning Big Chief Bc 31		3.2	24.0	64.3	11.7	2.4	13,220	7,344		900	13		Delivery
do.	1.2	1.8	23.8	66.7	9.5	2.6	13,855	7,697	2,480		4		do.
Indian Creek No. 1 Bc 30		3.0	24.3	64.7	11.5	2.4	13,340	7,411		650	8		do.
do.	2.9	3.3	24.2	64.2	8.3	2.0	13,690	7,606	2,350			98,568	Tipple
do.	1.9	2.3	24.1	62.4	11.2	2.4	13,420	7,456	2,490			A1,191	do.
do.	1.5	2.0	25.2	65.3	9.5	2.8	13,840	7,689	2,200		1	A55,051	do.
Kimmel Bc 29		3.7	23.9	64.7	11.4	2.8	13,230	7,350		250	4		Delivery
Melcroft Bc 12		2.2	25.7	63.5	10.8	2.2	13,540	7,522		850	13		do.
do.		2.7	25.0	64.3	10.7	2.5	13,440	7,467		400	8		do.
do.	2.4	2.9	24.6	61.3	11.2	2.6	13,220	7,344	2,390			98,546	Tipple
do.	1.6	2.0	24.3	68.1	10.6	2.4	13,530	7,517	2,400			A1,121	do.
do.		0.6	25.7	64.3	9.4	1.8	13,990	7,772	2,470			A55,006	do.

Table 3. Analyses of coal samples taken from the mine

U. S. Bureau of Mines

Mine and coal bed		Bureau of Mines Labora-tory No.	Proximate				Ultimate					Air-drying loss	Calorific value		
			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulphur	Hydro-gen	Carbon	Nitro-gen	Oxygen		British Thermal Units	Calories	Softening Temp. °F
Lower Kittanning Kuhn No. 2	Bc 34	81,470	2.7	22.2	67.2	7.4	2.3	4.8	78.9	1.4	5.2	1.9	13,990	7,772	2,255
Indian Creek No. 1	Bc 30	A1,195	3.0	23.5	65.5	8.0	1.7	4.9	78.5	1.3	5.6	2.4	13,910	7,728	
Melcroft	Bc 12	A1,127	3.1	24.0	64.1	8.8	2.2	4.9	77.2	1.3	5.6	2.6	13,730	7,628	
Sparks	Bc 33	A1,195	3.0	23.5	65.5	8.0	1.7	4.9	78.5	1.3	5.6	2.4	13,910		
Upper Freeport Miller	Bc 25	A95,569	2.2	23.7	63.1	11.0	3.8	4.7	75.4	1.4	3.7	1.7	13,520	7,511	2,270

Saltlick, and Springfield Townships in Fayette County (Hickok and Moyer, 1940) are used in this report. However, in some localities the identity of the coal was mistaken and it has been renamed for its correct correlative.

Pottsville Coals

Sharon coal horizon

The oldest coal horizon noted in the Donegal quadrangle lies about 10 feet above the base of the Pottsville Group. It is marked by a weathered outcrop of carbonaceous material and bleached-white plastic clay, occurring on the road west from St. Boniface Chapel (Ba 15) on Chestnut Ridge. This coal horizon is tentatively correlated with the Sharon coal as described by White (1891).

Quakertown coal

A coal bed occurring about 50 feet above the base of the Pottsville and between the lower and upper Connoquenessing sandstones, apparently corresponds to the position of the Quakertown in the lower part of the Pottsville as described by White (1891). This coal bed had been opened west of St. Boniface Chapel (Ba 16) and is reported to be 4 feet thick. Confirmation of this report could not be obtained. Blossoms of this coal were noted elsewhere in the area.

Mercer coal

The Mercer coal (White, 1891) lies at an average depth of 40 feet below the Brookville coal at the base of the Allegheny Formation and between the overlying Homewood and underlying Connoquenessing sandstones. The Mercer coal appears to be persistent along the outcrop on Chestnut Ridge and is of workable thickness locally. Mercer coal had been mined for custom trade north of Acme (Ab 20) where it is 30 inches thick, apparently of good quality and the bed is roofed by shale. The known maximum thickness of Mercer coal in the area was described in a test pit northwest of Rodney (Ab 9) and it is there 35 inches thick, of fairly good quality and overlain by about 15 feet of plastic clay. Sections of Mercer coal obtained at widely distributed localities on Chestnut Ridge are given below.

Occurrence of Mercer coal along its outcrop on the west limb of Laurel Hill is indicated by blossoms south of Weaver Mill (Cb 5), east of Roaring Run (Cc 1, 2), and on east limb of the anticline near Center Church (Cc 20).

Sections of Mercer coal
Outcrop, north of Ridge School (Ca 3)

	Feet	*Inches*
Sandstone		
Coal	2	0
Clay		

Test pit, northwest of Rodney (Ab 9)

	Feet	*Inches*
Sandstone		
Clay, plastic	15±	0
Coal	0	8
Shale parting	0	1
Coal	2	2½
Shale		
Thickness of bed:	2	11½
Thickness of coal:	2	10½

Abandoned country bank at Rassler Run (Ac 49)

	Feet	*Inches*
Sandstone		
Coal, bony	0	7
Coal	1	0
Shale	0	½
Coal	2	0
Clay		
Thickness of bed:	3	7½
Thickness of coal:	3	0

Allegheny Coals

Brookville (A) coal

On the basis of widely distributed points of observation, the Brookville coal at the base of the Allegheny maintains a generally minable thickness along its extensive outcrop on the limbs of Chestnut Ridge anticline (Plate 1). Thickness extremes range from 1 to 5 feet, but the weighted overall average thickness is about 3 feet. The bed commonly contains one or more nonpersistent partings or binders such as shale, clay, and pyrite (sulphur). Analyses of the coal were unobtainable, but the ash is reportedly about 13 percent. Carbonaceous shale containing relatively abundant siderite concretions commonly roofs the coal, and plastic clay, which in the zone of weathering contains scattered limonite nodules, forms the floor of the coal bed. The Brookville coal on Chestnut Ridge had been worked in country banks, and strip-mined recently in small operations. Sections of the coal bed obtained from various localities on Chestnut Ridge are assembled in tabular form below.

The Brookville coal is considered to constitute a future reserve where it underlies the flanks of Chestnut Ridge. The outcrop line and the distribution of reserves in thickness and reliability categories are shown on the coal resource map, Plate 3. The estimated reserves in "measured" and "indicated" categories are presented in Table 4. In summary, reserves in the combined reliability categories 28 inches and more thick underlie 25,609 acres which contains about 135,636,000 short tons of Brookville coal.

Table 4. Estimated known reserves of Brookville coal, 1961

TY	TOWNSHIP	AREA OF TOWNSHIP IN QUADRANGLE (ACRES)	AREAS EXCLUDED FROM ESTIMATE (ACRES)	AREAS OF COAL LOST BY EROSION (ACRES)	COAL OVER 14" THICK IN PLACE BEFORE MINING (ACRES)	MINED OUT AND LOST (ACRES)	COAL OVER 14" THICK REMAINING (ACRES)	MEASURED INDICATED INFERRED	COAL RESERVES IN TONS OF 2,000 POUNDS						TOTAL RESERVES IN TONS OF 2,000 POUNDS				RECOVERABLE RESERVES 28" AND MORE THICK - 50% RECOVERY
									14" TO 28" THICK		28" TO 42" THICK		OVER 42" THICK		14" AND MORE THICK		28" AND MORE THICK		
									ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	THOUSANDS OF TONS
FAYETTE	BULLSKIN	10,251.4		7,590.4	2,661.0		2,651.0	MEASURED			659.2	1,478	38.4	259	697.6	1,737	697.6	1,737	868
								INDICATED			1,963.4	9,949			1,963.4	9,949	1,963.4	9,949	4,974
								INFERRED											
								TOTAL			2,022.6	11,427			2,661.0	11,686	2,661.0	11,686	5,842
	SALTLICK	24,030.8	13,653.2	7,789.4	2,579.2		2,579.2	MEASURED			211.2	109			211.2	109	211.2	109	54
								INDICATED			2,368.0	12,233			2,368.0	12,233	2,368.0	12,233	6,116
								INFERRED											
								TOTAL			2,579.2	12,342			2,579.2	12,342	2,579.2	12,342	6,170
	SPRINGFIELD	9,236.0	4,592.8	2,278.2	2,834.4		2,934.4	MEASURED			192.0	1,008	288.0	2,119	480.0	3,127	480.0	3,127	1,563
								INDICATED			2,064.0	10,830	390.4	2,635	2,454.4	13,465	2,454.4	13,465	6,732
								INFERRED											
								TOTAL			2,256.0	11,838	678.4	4,754	2,934.4	16,592	2,934.4	16,592	8,295
WESTMORELAND	COOK	21,950.8	15,588.2	2,278.2	4,036.4		4,036.4	MEASURED			304.2	1,597	474.6	3,203	778.8	4,800	778.8	4,800	2,400
								INDICATED			1,721.6	9,038	1,536.0	10,368	3,257.6	19,406	3,257.6	19,406	9,703
								INFERRED											
								TOTAL			2,025.8	10,635	2,010.6	13,571	4,036.4	24,206	4,036.4	24,206	12,103
	DONEGAL	31,111.5	16,768.7	14,312.8	2,280.4		2,290.4	MEASURED			102.4	537	453.2	2,637	537.6	3,474	537.6	3,474	1,737
								INDICATED			1,166.0	6,279	556.6	3,758	1,752.8	10,037	1,752.6	10,037	5,018
								INFERRED											
								TOTAL			1,298.4	6,616	962.0	6,695	2,290.4	13,511	2,290.4	13,511	6,755
	LIGONIER	6,301.6	6,960.6	598.4	742.4		742.4	MEASURED											
								INDICATED					742.4	5,009	742.4	5,009	742.4	5,009	2,504
								INFERRED											
								TOTAL					742.4	5,009	742.4	5,009	742.4	5,009	2,504
	MOUNT PLEASANT	24,574.2	7,943.4	6,466.4	10,164.4		10,164.4	MEASURED			3,026.3	15,504	147.2	993	3,175.5	16,497	3,175.5	16,467	8,248
								INDICATED			6,700.6	32,661	288.0	1,944	6,988.9	34,605	6,988.9	34,605	17,302
								INFERRED											
								TOTAL			9,729.2	48,165	435.2	2,937	10,164.4	51,102	10,164.4	51,102	25,550
	UNITY	9,182.4	5,336.0	3,644.8	201.6		201.6	MEASURED					153.6	1,036	153.6	1,036	153.6	1,036	518
								INDICATED			48.0	252			48.0	252	48.0	252	126
								INFERRED											
								TOTAL			48.0	252	153.6	1,036	201.6	1,288	201.6	1,288	644
TOTALS		138,610.7	70,873.1	44,398.2	25,609.8		25,609.8	MEASURED			4,497.3	20,233	1,537.0	10,547	6,034.3	30,780	6,034.3	30,780	15,389
								INDICATED			16,061.9	81,242	3,513.6	23,714	19,575.5	104,956	19,575.5	104,956	52,478
								INFERRED											
								TOTAL			20,559.2	101,475	5,050.6	34,261	25,609.8	135,736	25,609.8	135,736	67,868

Table 5. Estimated known reserves of lower Kittanning coal, 1961

TOWNSHIP	AREA OF TOWNSHIP IN QUADRANGLE (ACRES)	AREAS OF COAL LOST BY EROSION (ACRES)	COAL OVER 14" THICK IN PLACE BEFORE MINING (ACRES)	MINED OUT AND LOST (ACRES)	COAL OVER 14" THICK REMAINING (ACRES)	MEASURED INDICATED INFERRED	COAL RESERVES IN TONS OF 2,000 POUNDS						TOTAL RESERVES IN TONS OF 2,000 POUNDS				RECOVERABLE RESERVES 28" AND MORE THICK-50 PERCENT RECOVERY
							14" TO 28" THICK		28" TO 42" THICK		OVER 42" THICK		14" AND MORE THICK		28" AND MORE THICK		
							ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	ACRES	THOUSANDS OF TONS	THOUSANDS OF TONS
BULLSKIN	10,251.4	7,968.2	2,287.6		2,287.6	MEASURED			268.8	1,206			268.8	1,206	268.8	1,206	603
						INDICATED			2,018.8	9,300			2,018.8	9,300	2,018.8	9,300	4,650
						INFERRED											
						TOTAL			2,287.6	10,506			2,287.6	10,506	2,287.6	10,506	5,253
SALTLICK	24,030.8	9,503.4	14,527.4	4,806.4	9,721.0	MEASURE	691.2	2,591	7,199.4	40,431			7,890.6	43,022	7,199.4	40,431	20,215
						INDICATED			1,830.4	9,868			1,830.4	9,868	1,830.4	9,868	4,934
						INFERRED											
						TOTAL	691.2	2,591	9,029.8	50,299			9,721.0	52,890	9,029.8	50,299	25,149
SPRINGFIELD	9,236.0	2,541.6	6,694.4	371.2	6,323.2	MEASURED	1,094.4	4,102	1,030.4	5,562			2,124.8	9,664	1,030.4	5,562	2,781
						INDICATED	2,265.6	8,493	1,932.8	10,438			4,198.4	18,931	1,932.8	10,438	5,219
						INFERRED											
						TOTAL	3,360.0	12,595	2,963.2	16,000			6,323.2	28,595	2,963.2	16,000	8,000
COOK	21,950.8	4,682.2	17,268.6		17,268.6	MEASURED			1,939.2	10,400			1,939.2	10,400	1,939.2	10,400	5,200
						INDICATED			5,878.2	28,992			5,878.2	28,992	5,878.2	28,992	14,496
						INFERRED			9,451.2	42,529			9,541.2	42,529	9,451.2	42,520	21,264
						TOTAL			17,268.6	81,921			17,268.6	81,921	17,268.6	81,921	40,960
DONEGAL	31,111.5	12,683.3	18,428.2	6.0	18,422.2	MEASURED			1,881.6	10,353	620.8	4,285	2,502.4	14,638	2,502.4	14,638	7,219
						INDICATED			6,851.6	35,206	857.6	5,913	7,709.2	41,119	7,709.2	41,119	20,559
						INFERRED			8,210.6	36,945			8,210.6	36,945	8,210.6	36,945	18,472
						TOTAL			16,943.8	82,504	1,478.4	10,198	18,422.2	92,702	18,422.2	92,702	46,350
LIGONIER	8,301.6	756.6	7,585.0		7,545.0	MEASURED			51.2	229			51.2	229	51.2	229	114
						INDICATED			1,654.6	7,443			1,654.6	7,443	1,654.6	7,443	3,721
						INFERRED			5,839.2	26,275			5,839.2	26,275	5,839.2	26,275	13,137
						TOTAL			7,545.0	33,947			7,545.0	33,947	7,545.0	33,947	16,972
MOUNT PLEASANT	24,574.2	7,808.3	16,765.9		16,765.9	MEASURED			275.2	1,237			275.2	1,237	275.2	1,237	618
						INDICATED			2,169.8	9,751			2,169.8	9,751	2,169.8	9,751	4,875
						INFERRED			14,320.0	64,439			14,320.0	64,439	14,320.0	64,439	32,218
						TOTAL			16,765.9	75,427			16,765.0	75,427	16,765.9	75,427	37,712
UNITY	9,182.4	4,044.7	5,137.7		5,137.7	MEASURED							5,137.7	23,121	5,137.7	23,121	11,560
						INDICATED											
						INFERRED			5,137.7	23,121			5,137.7	23,121	5,137.7	23,121	11,560
						TOTAL			5,137.7	23,121							
TALS	138,638.7	49,988.3	88,674.8	5,183.6	83,471.2	MEASURED	1,785.6	6,693	12,645.8	69,418	620.8	4,285	15,052.2	80,396	13,266.6	73,703	36,750
						INDICATED	2,265.6	8,493	22,336.2	110,998	657.6	5,913	25,459.4	125,404	23,203.8	116,911	58,454
						INFERRED			42,958.7	193,309			42,958.7	193,309	42,958.7	193,309	96,652
						TOTAL	4,051.2	15,186	77,940.7	373,725	1,478.4	10,198	83,470.3	399,109	79,429.1	383,923	191,856

	ACRES	THOUSANDS OF TONS
MEASURED	15,052.2	80,396
INDICATED	25,459.4	125,404
INFERRED	42,958.7	193,309
TOTAL	83,470.3	399,109

Sections of Brookville from localities on Chestnut Ridge

Country Bank, northwest of Ridge School (Ba 8)

(reported section)

	Feet	*Inches*
Shale		
Coal	4	0
Clay		

Country Bank, near Ridge School (Ba 18)

	Feet	*Inches*
Shale		
Clay, shale	1	6
Coal, bony	1	0
Coal	1	0
Shale	0	½
Coal, Knife-blade partings and sulphur streaks	2	11
Clay		
Thickness of bed:	4	11½
Thickness of coal:	3	11

Test pit west of Ridge School (Ba 17)

	Feet	*Inches*
Shale		
Coal, Knife-blade partings and sulphur streaks	4	0
Clay		

Strip mine, south of St. Boniface Chapel (Ba 24)

	Feet	*Inches*
Shale		
Coal, Knife-blade lenses of shale and sulphur streaks	3	3
Clay		

Test pit, north of Laurel Run School (Ba 32)

	Feet	*Inches*
Shale		
Coal, bony	0	6
Coal, Knife-blade lenses of shale and sulphur	3	4
Clay		

Country Bank, northwest of Laurel Run School (Ba 31)

	Feet	*Inches*
Shale		
Coal, bony	0	6
Coal, lenses of shale	4	3
Clay		

Custom mine, east of Kecksburg (Aa 31)

(Typical section)

	Feet	*Inches*
Shale		
Coal, sulphur streaks	1	4½
Clay	0	2
Coal	0	6
Shale	0	½
Coal, shale and sulphur streaks	2	6
Clay		
Thickness of bed:	4	7
Thickness of coal:	4	4½

Thickness range—30 to 60 inches.

Strip mine, east of Keeksburg (Aa 32)

	Feet	*Inches*
Shale		
Coal, shale and sulphur streaks	3	9½
Shale		

Strip mine, southeast of Keeksburg (Aa 38)

	Feet	*Inches*
Shale		
Coal, sulphur streaks	3	1
Clay		

Strip mine, east of Alice (Ab 6)

	Feet	*Inches*
Shale		
Coal, Knife-blade lenses of shale and sulphur	2	3
Clay		

Country bank, west of Acme (Ab 23)
(Reported section)

	Feet	*Inches*
Shale		
Coal, lenses of shale and sulphur	3	4
Clay		

Strip mine, southeast of Acme (Ab 25)
(Average section)

	Feet	*Inches*
Shale		
Coal, Knife-blade lenses of shale and sulphur	3	0
Clay		

Thickness range—32 to 40 inches.

Outcrop, south of Bear Rock School (Ab 35)
(Reported section)

	Feet	*Inches*
Shale		
Coal	2	5
Clay		

Thickness range—28 to 30 inches.

Test pit, west of Clinton (Ac 12)
(Typical section)

	Feet	*Inches*
Shale		
Coal	1	0
Shale	0	1
Coal	1	0
Shale	0	1
Coal	0	10
Thickness of bed:	3	0
Thickness of coal:	2	10

Country Bank, west of Rassler Run (Ac 46)

	Feet	*Inche*
Shale		
Coal, streaks of shale and sulphur	3	3
Clay		

Country Bank, southwest of Fairview School (Ac 31)
(Typical section)

	Feet	*Inches*
Shale		
Coal	0	8
Coal, bony	0	6
Coal, sulphur streaks	3	10
Shale	0	2
Coal	1	6
Clay		
Thickness of bed:	6	8
Thickness of coal (See analysis, Table 1)	6	0

The Brookville coal elsewhere in the Donegal quadrangle is almost unknown. Test holes 10 and 15 (Plate 2) found 1-inch and 24-inch beds of Brookville coal.

The following two sections were obtained on the west limb of Laurel Hill:

Country Bank, southwest of Saltlick (Bc 45)

	Feet	*Inches*
Sandstone		
Coal	1	0
Coal, bony	0	3
Coal	2	0
Clay		
Thickness of bed:	3	3
Thickness of coal:	3	0

Outcrop, east of Weaver Mill (Cb 4)

	Feet	*Inches*
Shale		
Coal	0	9
Shale	0	6
Coal, bony	0	5
Shale		

Lower Kittanning (B) coal

Large scale commercial mining began on the lower Kittanning coal in the Donegal quadrangle early in the present century along Indian Creek about Melcroft and Indian Head. In the first quarter of the century several coal mining companies were active in the area; one large mine is presently active (1962).

At the outset of mining, the operating companies were faced with the problem of disposal of mine water as required by law. They are not permitted to discharge drainage from mines into Indian Creek above the reservoir south of Normalville. A mutual company was formed to construct and maintain a main and branch flumes in which the drainage from various mines would collect and empty into Indian Creek below the reservoir. The flumes are partly on the surface, partly through abandoned workings, and partly through a tunnel that was driven for this purpose.

Melcroft no. 1 mine (Bc 12), the largest and only presently active mine was opened by Indian Creek Colleries Company about 1915, and was later acquired by Eastern Gas and Fuel Associates. The mine workings extend west from Champion Creek (Plate 4) to Wash Run, and north to near the township road running from Buchanon. The mined area (1961) covers approximately 2,900 acres. Melcroft no. 2 mine was a small development on the east side of Chapman Run (Bc 10).

Indian Creek Coal Company's no. 1 mine (Bc 30) and Kuhn no. 2 mine (Bc 34) worked about 1,100 acres west and south of Davistown. About 770 acres were mined east of Davistown and north of Indian Head in Kimmel (Bc 29), Big Chief (Bc 31) and Indian Head (Bc 33) mines. Indian Creek no. 2 (Bc 36), Saltlick (Bc 37) and Firestone (Ac 42) mines south of Indian Head were small operations of short duration that jointly mined about 95 acres.

Lower Kittanning coal was strip mined to some extent along Little Champion Creek (Ab 32-34, Ac 3, 4, 6), west of Buchanon (Ac 8, 10), south of Clinton (Ac 21) and west of Rasler Run (Ac 47, 48). At the latter locality strip mining on the lower Kittanning coal was active when visited in 1960. Removable overburden had about reached its limit, but the operators expected to recover additional coal by auger mining.

Since the economic depletion of the Pittsburgh coal in the Latrobe syncline, the lower Kittanning coal has become the most important coal bed in the Donegal quadrangle, and its horizon underlies a total of about 88,600 acres. The outcrop line follows irregularly along the foothills on the west slope of Laurel Hill, on the sides of the drainage valleys in the Ligonier syncline at the southwest, and along the east and west flanks of Chestnut Ridge; some lower Kittanning coal is contained in small erosional remnants on the crest of the ridge. The areal distribution and the line of outcrop of the lower Kittanning coal in the Donegal quadrangle is shown on Plate 4.

The lower Kittanning coal is known to be qualitatively and quantitatively minable along most of its extensive outcrop in the quadrangle, and core drill tests behind the outcrop or where the horizon is below drainage, almost invariably found lower Kittanning coal of uniformably minable thickness (Plate 2). In view of this coal's remarkably persistant minable habit in the Bituminous fields elsewhere in western Pennsylvania, it would seem reasonable to assume that the very large untested areas in the Donegal quadrangle contain great reserves of lower Kittanning coal.

Although there are local cutouts and extremes in thickness, the lower Kittanning coal ranges from 28 to 42 inches in thickness and averages about 40 inches thick. The bed is usually topped by a few inches of bony, and contains one or more nonpersistent shale partings; pyrite and/or marcasite occur as lenses and disseminated particles. Lenses of fusain are also present in the bed, and some of the fusain has been mineralized by "sulphur".

Measurements of the lower Kittanning coal bed obtained in various localities from deep mines, strip mines, core drill records, and outcrops are presented in the accompanying tabular sections.

Proximate analyses of run-of-mine, delivered and tipple samples, and proximate and ultimate analyses of mine samples are shown in tables 2 and 3, respectively. These analyses were taken from U. S. Bureau of Mines Technical Paper 590. Proximate analyses obtained from other sources are shown in Table 1.

Distribution of the reserves of lower Kittanning coal in reliability and thickness categories is shown on a coal resource map, Plate 4. Estimated reserves of the coal are shown on Table 5. In summary, approximately 5,000 acres underlain by lower Kittanning coal in the Donegal quadrangle have been exploited in commercial mining operations, and the estimated remaining reserves in all thickness and reliability categories amounts to about 83,470 acres and 399,107,000 short tons, all of which is under less than 1000 feet of cover.

Sections of lower Kittanning coal

Melcroft no. 1 mine, Melcroft (Bc 12)
(U. S. Bureau of Mines Technical Paper 590)
See analysis, Table 3.

Section Laboratory No.	A A1122		B A1123		C A1124		D A1125		E A1126	
	Ft.	In.	Ft.	In.	Ft	In	Ft	In.	Ft	In.
Roof, gray shale:										
Coal	2	7¼	2	11½	2	10	3	2½	2	10
Pyrite (local)		[a]2	—	—	—	—	—	—	—	—
Coal		7½	—	—	—	—	—	—	—	—
Floor, fire clay:										
Thickness of bed	3	4¾	2	11½	2	10	3	2½	2	10
Thickness of sample	3	2¾	2	11½	2	10	3	2½	2	16

[a] Not included in sample.

Section A (sample A1122) was taken at face of 1 left entry, B-flat entry, 800 feet southwest of mine mouth. Section B (sample A1123) was taken at neck of 12 room, 2 right entry, B-flat entry, 800 feet southwest of mine mouth. Section C (sample A1124) was taken at left rib, 6 room, 1 left entry, old C-flat entry, 2,500 feet northwest of mine mouth. Section D (sample A1125) was taken at face of 2 left entry, 4 left entry, 3000 feet northwest of mine mouth. Section E (sample A1126) was taken at face of 16 room, 7 left entry, 4000 feet northwest of mine mouth.

The ultimate analysis of a composite sample made by combining samples A1122 to A1126 is given under laboratory No. A1127.

Kuhn no. 2 mine, west of Indian Head (Bc 34)

(U. S. Bureau of Mines Technical Paper 590)
See analysis, Table 3.

Section Laboratory No.	A 81467		B 81468		C 81469	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof, slate:						
Bony coal		a5		a6		a6
Coal		5		11		4
Sulphur		¼		a2	....	....
Bony coal	....	....	....	....		a½
Bone		a½	....	....	....	....
Coal		4	1	11	2	8½
Bone		a½	....	....	....	....
Coal	2	2¾	....	....	....	....
Floor, Fireclay:						
Thickness of bed	3	6	3	6	3	7
Thickness of sample	3	0	2	10	3	½

a. Not included in sample.

Section A (sample 81467) was taken at face of left entry. Section B (sample 81468) was taken on right rib, main heading, 20 feet from face. Section C (sample 81469) was taken at face of 2 right entry.

The ultimate analysis of a composite sample made by combining samples 81467 to 81469 is given under laboratory No. 81470.

Sparks no. 1 mine at Indian Head (Bc 33)

(U. S. Bureau of Mines Technical Paper 590)
See analysis, Table 3.

Section Laboratory No.	A A1192		B A1193		C A1194	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof, gray shale:						
Coal		4	3	6½	3	¾
Sulphur (local)		¼	....	....	....	....
Coal	1	7¾	....	....	....	....
Sulphurous mother coal		a¾	....	....	....	....
Coal	1	5¼	....	....	....	....
Floor, sandy fireclay:						
Thickness of bed	3	6	3	6½	3	¾
Thickness of sample	3	5¼	3	6½	3	¾

a. Not included in sample.

Section A (sample A1192) was taken at face of main heading, 4,000 feet west of mine mouth. Section B (sample A1193) was taken at face of 6 left main heading, 4,000 feet southwest of mine mouth. Section C (sample A1194) was taken at face of 2 right main heading, 2,600 feet northwest of mine mouth.

The ultimate analysis of a composite sample made by combining samples A1192 to A1194 is given in laboratory No. A1195.

Melcroft no. 1 mine (Bc 12)

	Feet	*Inches*
Shale		
Coal, bony	0	6
Coal	3	4
Clay		

Big Chief mine at Sagamore (Bc 31)

	Feet	*Inches*
Shale		
Coal, bony	0	6
Coal	2	10
Clay		

Saltlick mine (Bc 37)

	Feet	*Inches*
Sandstone		
Coal, bony	0	7
Coal	1	0
Coal, bony	0	½
Coal	2	0
Clay		
Thickness of bed:	3	7½
Thickness of coal:	3	0

Core drill hole, northeast of Indian Head (Bc 32)

	Feet	*Inches*
Shale		
Coal, bony	0	6
Shale	0	1
Coal	3	5

Core drill hole, east of Melcroft (Bc 17)

	Feet	*Inches*
Shale		
Coal, bony	0	6½
Coal	3	4
Clay		

Core drill hole, east of Melcroft (Bc 18)

	Feet	*Inches*
Shale		
Coal, bony	0	7½
Coal	3	4
Clay		

Core drill hole, east of Melcroft (Bc 21)

	Feet	*Inches*
Shale		
Coal, bony	0	7
Coal	3	4
Clay		

Core drill hole, southeast of Melcroft (Bc 27)

	Feet	*Inches*
Shale		
Coal, bony	0	5
Shale	0	1½
Coal	3	5
Clay		

Core drill hole, east of Melcroft (Bc 23)

	Feet	Inches
Shale		
Bony coal	0	6½
Shale	0	1½
Coal	3	8
Clay		

Core drill hole, northeast of Melcroft (Bc 9)

	Feet	Inches
Sandstone		
Rash	0	¾
Bone	0	2
Coal, sulphur streaks	1	1¾
Coal, laminated	0	2¼
Coal, sulphur streaks	1	8¾
Slate	0	¼
Coal, sulphur streaks	0	1
Clay		
Thickness of bed:	3	7¼
Thickness of coal:	3	1⅜

Core drill hole, east of Melcroft (Bc 14)

	Feet	Inches
Shale		
Bony coal	0	7
Coal	3	4
Clay		

Core drill hole, northeast of Melcroft (Bc 8)

	Feet	Inches
Sandstone		
Coal	0	5
Binder	0	2
Coal	3	5
Clay		

Core drill hole at Maple Grove (Bc 15)

	Feet	Inches
Sandstone		
Shale	0	5
Coal	3	5
Clay		

Core drill hole, west of Melcroft (Bc 28)

	Feet	Inches
Shale		
Coal	4	0
Clay		

Core drill hole, west of Roaring Run (Bc 4)

	Feet	Inches
Sandstone		
Bony coal	0	2¼
Coal	3	1½
Clay		

Core drill hole, west of Roaring Run (Bc 5)

	Feet	Inches
Shale		
Bony coal	0	6
Coal	3	6
Clay		

Core drill hole, west of Roaring Run (Bc 3)

	Feet	*Inches*
Sandstone		
Rash	0	3¼
Shale	0	2
Coal, sulphur streaks	1	1½
Coal, laminated	0	2½
Coal, sulphur streaks	2	⅞
Clay		
Thickness of bed:	3	10⅛
Thickness of coal:	3	4⅞

Core drill hole, west of Roaring Run (Bc 2)

	Feet	*Inches*
Shale		
Rash	0	4½
Shale	0	2
Coal	0	11
Coal, laminated	0	4½
Coal	1	7
Clay		
Thickness of bed:	3	5
Thickness of coal:	2	10½

Core drill hole, west of Roaring Run (Bc 5)

	Feet	*Inches*
Sandstone		
Bony coal	0	2¼
Coal, sulphur streaks	0	7
Coal, laminated	0	3¾
Coal, sulphur streaks	2	2¾
Clay		
Thickness of bed:	3	3¾
Thickness of coal:	3	1½

Core drill hole, northwest of Roaring Run (Bc 24)

	Feet	*Inches*
Rash	0	3¾
Shale	2	2⅜
Coal, sulphur streaks	1	2½
Coal, laminated	0	1¾
Coal, sulphur streaks	1	10½
Clay		
Thickness of bed:	5	8⅞
Thickness of coal:	3	2¾

Core drill hole, south of Donegal (Bb 17)

	Feet	*Inches*
Shale		
Bony coal	0	8
Coal	3	6
Clay		

Core drill hole, south of Donegal (Bb 14)

	Feet	*Inches*
Shale		
Bony coal	0	7
Coal	3	0
Clay		

Strip mine, northeast of Buchanan (Ab 32)

	Feet	*Inches*
Shale		
Bony coal	1	4
Coal	2	8
Clay		

Strip mine, northeast of Buchanan (Ab 33)

	Feet	*Inches*
Shale		
Bony coal	0	6
Coal	3	3
Clay		

Strip mine, east of Buchanan (Ac 3)

	Feet	*Inches*
Shale		
Bony coal	0	8
Coal	3	11
Clay		

Strip mine, east of Buchanan (Ac 4)

	Feet	*Inches*
Shale		
Bony coal	0	10
Coal	3	10
Clay		

Strip mine, northwest of Buchanan (Ac 7)

	Feet	*Inches*
Shale		
Bony coal	0	6
Coal	3	4
Clay		

Strip mine, west of Buchanan (Ac 8)

	Feet	*Inches*
Shale		
Bony coal	1	0
Coal	2	8
Clay		

Country bank, west of Buchanan (Ac 10)

	Feet	*Inches*
Shale		
Bony coal	0	4
Coal	3	4
Clay		

Strip mine, south of Clinton (Ac 21)

	Feet	*Inches*
Sandstone		
Coal	3	0
Clay		

Core drill hole, south of Jockey Knob (Ac 26)

	Feet	*Inches*
Shale		
Coal	3	0
Clay		

Core drill hole, south of Jockey Knob (Ac 27)

	Feet	*Inches*
Shale		
Bony coal	0	4
Shale	0	2
Coal	2	8½
Shale		

Core drill hole, south of Jockey Knob (Ac 28)

	Feet	*Inches*
Shale		
Coal	3	5½
Clay		

Core drill hole, south of Jockey Knob (Ac 34)

	Feet	*Inches*
Shale		
Bony coal	3	1
Clay		

Core drill hole, south of Jockey Knob (Ac 35)

	Feet	*Inches*
Shale		
Bony coal	0	4
Shale	0	3½
Coal	2	10½
Clay		

Core drill hole, northwest of Saltlick (Ac 36)

	Feet	*Inches*
Shale		
Coal	3	3
Clay		

Core drill hole, northwest of Saltlick (Ac 37)

	Feet	*Inches*
Shale		
Coal	3	3
Shale		

Core drill hole, northwest of Saltlick (Ac 38)

	Feet	*Inches*
Shale		
Coal	3	3
Shale		

Country bank, west of Fairview School (Ac 30)

	Feet	*Inches*
Shale		
Coal	0	1½
Shale	0	4
Coal	0	7½
Clay	0	5
Coal	2	4
Clay		

Strip mine, west of Rasler Run (Ac 47)

	Feet	*Inches*
Shale		
Coal	2	5
Clay		

Strip mine, west of Rasler Run (Ac 48)

	Feet	Inches
Shale		
Coal	2	4
Clay		

Outcrop, northeast of Jones Mill (Cb 17)

	Feet	Inches
Shale		
Coal	1	0
Shale	1	0
Bony coal	0	2
Coal	1	5
Shale	0	2
Coal	1	5
Clay		

Blair mine, east of Franklin (Cb 9)

	Feet	Inches
Shale		
Bony coal	0	3
Coal, sulphur streaks	4	3
Shale	0	¼
Coal	0	2
Shale	0	¼
Coal	0	2
Clay		

Hunter mine, northeast of Franklin (Cb 6)

	Feet	Inches
Shale		
Bony coal	0	2
Coal, sulphur streaks	3	6
Clay		

Strip mine, east of Weaver Mill (Cb 3)

	Feet	Inches
Shale		
Bony coal	0	4
Coal, sulphur streaks	3	4
Clay		

Country bank, northeast of Ridge School (Ca 4)

	Feet	Inches
Sandstone		
Coal	1	8
Bony coal	0	3
Coal	0	7
Clay		
Thickness of bed:	2	6
Thickness of coal:	2	0

Test pit, south of St. Boniface Chapel (Ba 23)

	Feet	Inches
Sandstone		
Bony coal	0	10
Coal	1	0
Shale		1½
Coal	2	1
Thickness of bed:	4	½
Thickness of coal:	3	1

Strip mine, south of Rodney (Ab 15)

	Feet	Inches
Shale		
Coal, sulphur streaks	2	0
Shale	0	½
Coal	0	9
Shale	0	2
Clay		
Thickness of bed:	2	11½
Thickness of coal:	2	9

Middle Kittanning (C) coal

The middle Kittanning coal is a fairly persistent coal though not one of the major coals in the Allegheny Formation. Although it is commercially productive locally, it is generally noted as being thin and sporadic in occurrence in western Pennsylvania. In the Donegal quadrangle, the middle Kittanning coal lies about 100 feet above the horizon of the Brookville coal. It apparently maintains a persistently minable thickness along its outcrop in southwestern Saltlick and northwestern Springfield Townships, where it ranges from 26 to 46 inches and averages 35 inches thick. The bed contains nonpersistent knife blade shale partings and lenses of sulphur; the roof is shale and the floor is clay.

Middle Kittanning coal was worked in country banks and strip mined commercially east and southeast of Clinton (Ac 14, 15, 17, 19, 22, 23) and along Rasler Run (Ac 20, 29, 32, 45). The strip mine on the east side of Rasler Run extends continuously for about 2 miles (Ac 20 to 45). Systematic core drill testing on the above localities may reveal extensive minable reserves for eventual deep mining.

As indicated in the widely spaced core drill holes put down in the area south from Donegal to northwest of Frogtown (Plate 2), the middle Kittanning coal is thin, cut out by sandstone, and the thicker coal contains relatively thick partings. The middle Kittanning coal, 41 inches thick, was strip mined in a small operation at Rodney (Ab 14).

Following are sections of the middle Kittanning coal from various localities in the southwestern part of the Donegal quadrangle. See also sections on Plate 2.

Sections of middle Kittanning coal

Country bank, east of Clinton (Ac 14)

	Feet	Inches
Shale		
Coal	3	0
Clay		

Country bank, east of Clinton (Ac 15)

	Feet	*Inches*
Shale		
Bony coal	0	5½
Coal	3	0
Clay		

Strip mine, southeast of Clinton (Ac 23)

	Feet	*Inches*
Shale		
Coal	3	1
Clay		

Country bank, southeast of Clinton (Ac 17)

	Feet	*Inches*
Shale		
Coal	2	10½
Clay		

Outcrop, west of Jockey Knob (Ac 24)

	Feet	*Inches*
Shale		
Coal	2	10
Clay and limestone		

See analysis, Table 1.

Strip mine, southwest of Fairview Schoole (Ac 32)

	Feet	*Inches*
Shale		
Bony coal	0	6
Clay	0	4
Coal	3	10
Clay		

Country bank, east of Mt. Zion Church (Ab 31)

	Feet	*Inches*
Shale		
Coal	1	4
Shale		1½
Coal	1	6
Clay		
Thickness of bed:	2	11½
Thickness of coal:	2	10

Core drill hole, north of Melcroft (Bb 24)

	Feet	*Inches*
Shale		
Coal	1	6½
Clay		1½
Coal	1	7
Shale	0	1
Coal	1	3
Clay		
Thickness of bed:	4	7
Thickness of coal:	4	4½

Strip mine, at Rodney (Ab 14)

	Feet	*Inches*
Shale		
Coal	3	5
Clay		

Upper Kittanning (C') coal

The upper Kittanning coal is of good quality and is mined commercially at numerous localities in western Pennsylvania. It is reported to be persistently minable in Somerset County (Richardson, 1934; Flint, 1956) and in Fayette County (Hickok and Moyer, 1940).

Very little information about the upper Kittanning coal was available in the Donegal quadrangle where its horizon lies about 90 feet below the Upper Freeport. It was strip mined in a small operation at Rodney (Bb 2) where it has a bed thickness of 8 feet, 9 inches, but it contains numerous shale partings and lenses of sulphur (See section below). The coal was also strip mined in a small operation to the south near Acme (Ab 21). The pit was back-filled but it was reported that the coal ranged from 46 to 56 inches thick.

As indicated in the sections of core drill holes in the southwestern part of the Ligonier Valley, (Plate 2) thin upper Kittanning coal is logged only in sections 11, 12, and 13. It could be assumed therefore that extensive minable deposits of upper Kittanning coal are doubtfully present in the tested and adjacent areas.

Section in strip mine on upper Kittanning coal (Bb 2)

	Feet	*Inches*
Shale		
Coal, Lower Freeport	1	8
Shale	20	0
Bony coal	1	0
Coal	2	2
Shale	0	½
Coal	0	4½
Shale	0	7½
Coal	0	9
Shale	0	¾
Coal	0	4
Shale		¾
Coal	2	10
Coal		
Clay		
Thickness of bed:	8	9
Thickness of coal:	6	5½

Lower Freeport (D) coal

The lower Freeport coal has undergone large-scale commercial exploitation at many localities in the bituminous coal fields. It is the valuable "Moshannon" coal of the Moshannon basin in Centre County and the "Reynolds gas" coal in the Reynolds basin in Jefferson County. The lower Freeport coal which occurs about 50 feet below the upper Freeport coal is not mined in the Donegal quadrangle, and although available data are meager, indications are that extensive workable deposits of good quality lower Freeport coal probably are lacking. Most of the information about the coal is from the core drill tested area in the Ligonier Valley about Melcroft

(Plate 2) where the Lower Freeport coal is generally thin or missing, and the local relatively thick beds contain impurities. Sections of lower Freeport coal obtained at widely distributed points along the outcrop are given below. See also sections of lower Freeport coal on Plate 2.

Sections of lower Freeport coal

Test pit, east of Weltytown (Aa 28)

	Feet	*Inches*
Sandstone		
Shale	10	0
Coal	1	6
Shale	0	1½
Coal	0	4
Shale		1½
Coal	1	1
Clay		
Thickness of bed:	4	2
Thickness of coal:	2	11

Test pit, south of Alice (Ab 12)

	Feet	*Inches*
Sandstone	20±	
Shale, variable		
Coal, knife blade shale partings and sulphur streaks	4	0
Clay		

Strip mine at Rodney (Bb 2)

	Feet	*Inches*
Shale		
Coal, Lower Freeport	1	6
Shale	20	0
Coal, Upper Kittanning		

Exposure, on Turnpike south of Rodney (Bb 4)

	Feet	*Inches*
Shale		
Coal	1	7
Clay		

Outcrop west of Saltlick (Ac 40)

	Feet	*Inches*
Shale		
Coal	1	2
Shale	0	2
Coal	1	3
Clay		
Thickness of bed:	2	7
Thickness of coal:	2	5

Country bank, south of Saltlick (Ac 43)

	Feet	*Inches*
Sandstone		
Coal	4	10
Bony coal	1	0
Shale	0	2
Bony coal	0	8
Thickness of bed:	6	8
Thickness of coal:	4	10

Outcrop north of Weaver Mill (Ca 25)

	Feet	Inches
Shale		
Bony coal	1	2
Clay	1	8
Bony coal	1	8
Clay		

Upper Freeport (E) coal

The upper Freeport coal at the top of the Allegheny Group ranks as one of the more commercially important coal beds in western Pennsylvania, and it is rated second to the lower Kittanning coal in regional minable persistence. The Upper Freeport is known as the "Cap seam" in the Moshannon basin in Centre County, the "Lemon coal" in Cambria and Blair Counties, and the "Coke yard seam" in the Johnstown basin.

The upper Freeport coal has not attracted commercial interest in the Donegal quadrangle, and the residents have mined only minor quantities of this coal for local use. Points of definite information about the coal bed along its very extensive outcrop are therefore few and widely distributed. As indicated from these limited observations, the bed thickness of the coal ranges from 28 to 48 inches, and commonly contains one or more shale and/or clay partings, which locally are relatively thick and would have to be removed from the coal by a cleaning process to obtain a marketable product under modern acceptable standards. Sections of the upper Freeport coal obtained at the outcrop at various localities in the quadrangle are represented below.

Erratic occurrence of the upper Freeport coal in the Ligonier Valley about Melcroft is indicated in the sections of core drill holes on Plate 2, which show that the coal is generally thin, is locally cut out by sandstone, and that the local thicker beds contain relatively thick partings and binders.

If an overall appraisal of the value of the upper Freeport coal in the Donegal quadrangle were made on the basis of the poor density of information available, it would appear unlikely that extensively minable reserves of the coal are present. However it is unwise to condemn the area as a whole. The horizon of the coal underlies 63,370 acres in the Donegal quadrangle and its maximum depth below the surface is less than 1000 feet. Considering the favorably reputable habit of the Upper Freeport elsewhere in the bituminous fields, it would seem reasonable to assume that this large untested area in the quadrangle is a potential reserve of qualitatively and quantitatively minable upper Freeport coal.

Sections of upper Freeport coal
(See also Plate 2)

Country bank, northwest of Bethel Church (Ba 19)

	Feet	Inches
Shale		
Coal	1	8
Shale	0	2
Coal	1	8
Clay		
Thickness of bed:	3	6
Thickness of coal:	3	4

Outcrop, east of Pleasant Grove (Ca 19)

	Feet	Inches
Shale		
Coal	2	0
Shale	0	¾
Coal	1	5
Clay		
Thickness of bed:	3	5¾
Thickness of coal:	3	5

Outcrop, near Weaver Mill (Cb 1)

	Feet	Inches
Shale		
Coal	2	4
Clay		

Exposure of Turnpike northeast of Franklin (Cb 8)

	Feet	Inches
Shale		
Bony coal	0	6
Coal	0	10½
Shale	0	¼
Coal	0	7½
Shale	0	5½
Coal	0	4
Clay		
Thickness of bed:	2	9¾
Thickness of coal:	1	10

Country bank, northeast of Rodney (Bb 1)

	Feet	Inches
Shale		
Bony coal	0	6
Coal, thin partings	3	0
Clay		

Test pit, east of Rodney (Bb 3)

	Feet	Inches
Shale		
Coal	0	3
Shale	0	1
Coal	0	5½
Fusain	0	½
Coal	0	6
Shale	0	1
Coal	0	5½
Shale	0	2
Coal	0	10
Clay		
Thickness of bed:	2	10½
Thickness of coal:	2	6

Country bank, Horners Mill (Cb 13)
(Reported section)

	Feet	Inches
Shale		
Coal	2	10
Clay		

Country bank, north of Jones Mill (Bb 22)
(Reported section)

	Feet	Inches
Shale		
Coal	3	0
Clay		

Country bank, west of Jones Mills (Bb 19)

	Feet	Inches
Sandstone		
Coal	2	1
Shale	0	1
Coal	1	5
Coal		
Clay		
Thickness of bed:	3	7
Thickness of coal:	3	6

Country bank, west of Roaring Run (Bc 6)

	Feet	Inches
Sandstone		
Bony coal	0	4
Coal	1	8½
Clay		1½
Coal	1	3½
Clay		
Thickness of bed:	3	5½
Thickness of coal:	3	0

Country bank, east of Sagamore (Bc 26)

	Feet	Inches
Shale		
Coal	1	7
Clay	0	2½
Coal	0	11
Clay		
Thickness of bed:	2	8½
Thickness of coal:	2	6

Country bank, east of Sagamore (Bc 25)

	Feet	Inches
Shale		
Bony coal	0	7
Coal	1	11½
Clay	0	3
Coal	1	1
Clay		
Thickness of bed:	3	10½
Thickness of coal:	3	½

(See analysis, Table 3)

Country bank, east of Saltlick (Bc 38)

	Feet	*Inches*
Shale		
Coal	1	11
Clay	0	1
Coal	0	5
Clay	0	1½
Coal	0	2
Clay		
Thickness of bed:	2	8½
Thickness of coal:	2	6

Outcrop, west of Saltlick (Ac 41)

	Feet	*Inches*
Sandstone		
Coal	1	2
Shale	0	½
Coal	1	5
Shale	0	5
Coal	1	0
Clay		
Thickness of bed:	4	½
Thickness of coal:	3	7

Country bank, west of Normalville (Ac 44)

	Feet	*Inches*
Shale		
Coal	1	8
Shale	0	½
Coal	0	5½
Clay		
Thickness of bed:	2	2
Thickness of coal:	2	1½

Country bank, south of Buchanan (Ac 11)

	Feet	*Inches*
Shale		
Bony coal	0	4
Coal	2	4
Shale	0	¼
Coal	0	2
Clay	0	1¼
Coal	1	½
Clay		
Thickness of bed:	4	0
Thickness of coal:	3	6½

Exposure on Turnpike north of Laurelville (Ab 5)

	Feet	*Inches*
Shale		
Coal	2	¼
Shale		¾
Coal	0	2
Shale	0	1¾
Coal	1	0
Shale	0	1¾
Coal	0	7
Clay		
Thickness of bed:	4	1½
Thickness of coal:	3	9¼

Pittsburgh Coal

The Pittsburgh coal in the Latrobe syncline in the Donegal quadrangle covered 8,240 acres which contained an original reserve of approximately 114,000,000 tons. According to Eavenson (1938) first mining on the Pittsburgh coal in the area began in 1872. Large scale commercial operations began about 1888 and continued to about 1930 when economic commercial extraction was finished. The estimated total production is approximately 77,520,000 tons. After abandonment by the large operators, pillars left for roof support were leased to small local operators and small scale deep and strip mining continued to about the middle part of this century. The U. S. Bureau of Mines (1951) reported an estimated 1,085 acres in the Donegal quadrangle containing 9,550,000 tons of Pittsburgh coal, presumably in small solid blocks and recoverable pillars. However, the old mine workings are now largely flooded.

The Pittsburgh coal in the Latrobe syncline was very regular and had an average thickness of 84 inches; it is commonly roofed by dark shale. The coal bed consisted of three main divisions. The upper division or roof coal consisted of alternating layers of coal and shale, the main bench was in two parts and consisted of the "breast" or clean coal at the top and the "bearing-in" coal below, under which was the bottom or "brick" coal. A typical section of the Pittsburgh coal bed in the Latrobe syncline is as follows:

Typical section of Pittsburgh coal bed

	Feet	*Inches*
Roof, dark shale, locally silty	15±	0
Upper division or roof coal		
Alternating layers of coal and shale	4	0
Partings, clay or shale	2	6
Lower or main division		
Brest coal, fairly clean	5	10
Bearing-in coal		
Shale	0	¼
Coal	4	6
Shale	0	1
Lower, bottom or brick coal	3	0
Floor, clay		

Following is a list of former large coal companies and their abandoned mines in the Donegal quadrangle:

H. C. Frick Coke Co. (recently acquired by U. S. Steel Co.)
    Mutual (Aa 2), Trauger (Aa 15) Calumet (Aa 23), Mammoth (Aa 26)
Humphries Coal and Coke Co., Humphry (Aa 1)
Jamison Coal and Coke Co., Pleasant Unity (Aa 7)
Hecla Coke Co., Hecla (Aa 10)
Clare Coke Co., Clare (Aa 9)

Coal Reserves

Previous and present estimates

Reese and Sisler (1928) estimated the coal reserves in Fayette and Westmoreland Counties. Their estimates were based on a compilation of available data as of 1922. Moyer (1940) revised the Reese and Sisler estimate in Fayette County on the basis of detailed geologic mapping, and a relative abundance of coal data. In 1943, the U. S. Bureau of Mines began a program for an investigation with a prime objective of estimating the known reserves of coal that were or could be made suitable for manufacture of metallurgical coke, together with such additional reserves as may become economically minable under future conditions of improved technology.

Some of these data were published in U. S. Bureau of Mines Reports of Investigations 4807 and 4803 (1951), "Estimate of known recoverable reserve of coking coal in Fayette and Westmoreland Counties" respectively. Report 4803 gives an estimate of reserves only for the Pittsburgh coal in the Donegal quadrangle (see page 79). Production of Pittsburgh coal has been negligible in the Latrobe syncline since the estimate was published in 1951 and the reserves as reported are therefore considered to be adequate for the present. Reserves of Allegheny coals in Westmoreland County in the quadrangle have not been estimated presumably because of insufficient coal data and lack of detailed geology. Report 4807 is essentially a revision of the estimates in Fayette County made by Moyer (1940) giving reserves of the Brookville-Clarion, lower Kittanning, and upper Freeport coals.

Field investigation for this report found available data sufficient only for computation of reserves of the Brookville and lower Kittanning coal beds. Estimates of the reserves of these coals in thickness and reliability categories are given in Tables 4 and 5 respectively; and their distribution in similiar classifications are shown on Plates 3 and 4 respectively.

Procedures and definitions

Procedures and definitions employed for appraisal, estimating, and reporting estimates of coal reserves have been standardized to give uniformity, and have been adopted by the U. S. Bureau of Mines, U. S. Geological Survey (U.S.G.S. Circular 94; Coal Resources of the United States, 1950), and most of the state geological surveys. The methods and procedures employed in the present estimate are based upon the same premises and systems of classification, and differ only in degree, based upon the personal opinion of the observer.

Base maps to the scale of 1:62,500 feet were made for each coal bed. The outcrop of the bed and all available data from mine maps, core drill holes and measurements from small mines and outcrops was plotted. Uncertain data such as reports of coal in inaccessible small workings and strong "blossoms" at the outcrop was used to supplement exact data. With all of the data plotted, arbitrary lines were drawn limiting areas of reserves in beds 14 to 28 inches thick, 28 to 42 inches thick and over 42 inches thick. These areas were divided into reliability categories of "measured", "indicated", and "inferred" reserves. All of the areas in each category were measured by planimeter. Estimates of the reserves and the reserve maps were prepared from these work maps.

Unit area

Reserves are reported for townships and parts of townships (boroughs are included with the nearest township) within the quadrangle so that they may be combined in county, state, and national totals.

Overburden

All of the reserves in the "measured" and "indicated" classes are under less than 1000 feet of cover, and relatively small amounts of "inferred" reserves are under more than 1,000 feet of cover.

Classes of reserves

On the basis of abundance of reliable data, the reserves are reported in three separate reliability categories, known as "measured", "indicated" and '"inferred".

Measured coal

The outer limits of continuity of measured coal is established by radii from a point of observation. The length of the radius is arbitrarily adjusted according to the reputable habit of the coal bed. For coals having favorable regional distribution, such as the Lower Kittanning, ½ mile is assumed to be the outer limit of measured coal, and an arc with a ½ mile radius is scribed about the point of observation. The outline of intersecting and nearly intersecting arcs was smoothed to minimize unrealistic geometric patterns. The computed tonnage of measured coal is judged to be within 20 percent or less of the true tonnage.

Indicated coal

The area of indicated coal lies beyond the limits of measured coal, and is based largely on geologic probability. Tonnage is computed from projection of observed data, supplemented by indicated data for reasonable distances. For coal beds of favorable geologic continuity, the outer limit of indicated coal extends 1½ miles beyond the points of definite data, thus forming a band 1 mile wide around the outer limits of measured coal.

Inferred coal

Inferred coal is coal for which quantitative estimates are based largely on broad knowledge of the geologic habit of the bed or region and for which there are few, if any, measurements. The estimates are based on the assumed continuity for which there is geologic evidence. This category includes all coals beyond the outer margin of indicated coal. Inferred reserves were computed only for the lower Kittanning coal in the Donegal quadrangle which involves very great areas in the Latrobe and Ligonier synclines.

Thickness of beds

Coal reserves are calculated and reported by beds in categories of thickness as follows:

14 to 28 inches
28 to 42 inches
More than 42 inches

The thickness of beds used in making the reserve calculations is obtained from weighted average figures, expressed to the nearest whole inch. Partings of more than three-eights inch thick are omitted in determining the thickness of individual beds. Top and bottom benches of coal that normally would be left in mining are also omitted.

Weight of coal

Estimated tonnage of coal in place is based on an average weight of 1,800 short tons per acre foot, or 150 tons per acre inch.

Percentage of recovery

The result of other estimates indicate that from the total resource point of view, the recoverability of coal in the ground is about 50 percent. This includes coal that must legally be left unmined such as barrier pillars and blocks of coal under towns, roads, railroads, and streams.

Recoverable reserves

The recoverable reserves are based on a bed thickness of 28 inches, which is the minimum bed thickness being mined by hand-loaded conveyors in the bituminous fields.

Mined out and lost.

The area within the limits of the developed area of a mine is taken as mined out and lost. But no attempt was made to determine the amount of coal left in pillars that possibly could be recovered in mining.

The estimates of reserves of coal given in the accompanying tables are not to be taken as exact, but rather as provisional. They are intended to serve as preliminary evaluation of coal lands as guides for future prospecting.

NATURAL GAS

A deep reservoir of natural gas was discovered in the Donegal quadrangle when Peoples Natural Gas Co's. William Piper no. 1 well was completed on August 17, 1947. This well, located on the crest of Chestnut Ridge anticline (Ba 6), found economically productive volumes of natural gas in the Onondaga limestone (Middle Devonian) and the underlying Oriskany sandstone (Lower Devonian). Leasing drilling, and seismic exploration have become increasingly active in the area since this discovery. At present (1961) two gas fields, each with two distinctive gas pools have been developed. (Fig. 13, see also Plate 1.) The Lycippus field is on Chestnut Ridge anticline; it contains the Piper pool at the north and the St. Boniface Chapel pool at the south. The Seven Springs field is on Laurel Hill anticline; it contains the Blair pool at the north and the Kooser pool at the south. Twenty-eight wells have been drilled in the respective fields, of which 15 yielded economic volumes of gas. Nearly all of the gas was accumulated in the chert section of the Onondaga limestone, which contained fractures that served as a reservoir. Some wells found only "shows" of gas in the chert, but after fracturing the yield of gas was increased to very large volumes with high reservoir pressures.

Summarized records of the wells drilled for natural gas in the Donegal quadrangle are assembled on Table 6. A sample log of Fred Musnug no. 2 well on Chestnut Ridge anticline (Ba 10) and Adolph Dupree no. 1 well on Laurel Hill anticline (Cc 10) appear on pages 8, and 22, respectively.

Lycippus Gas Field

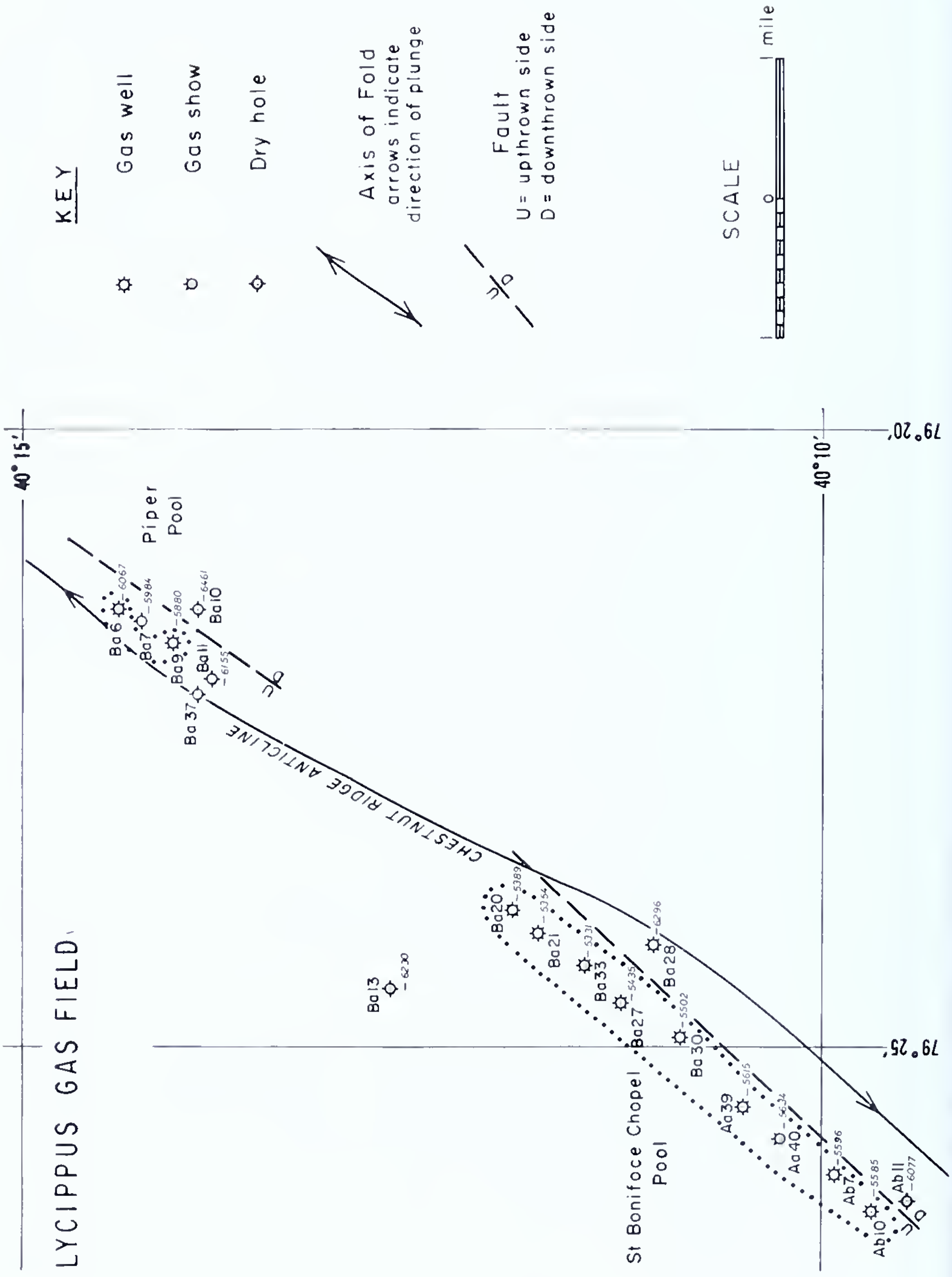
The Lycippus Gas Field (Fig. 13) is on an elongated dome of Chestnut Ridge anticline, that extends about 8 miles northeastward from Jacobs Creek to the north boundary of the quadrangle. Eighteen wells have been drilled in the field, of which 11 were economically successful. The combined initial yield of the productive wells amounts to 59,200 m.c.f. (thousand cubic feet) of gas, and the initial reservoir pressures ranged from 3,000 to 4,100 p.s.i. (pounds per square inch). The combined total depth of the wells is 144,333 feet or approximately 27.3 miles; the average total depth is about 8,000 feet.

As indicated in the sample log of Fred Musnug no. 2 well (page 11), the Upper Devonian is 6750 feet thick, and the Middle Devonian is 800 feet thick. Driller's logs indicate that the Tully limestone has an average thickness of 80 feet; its base lies at an average of 528 feet above the top of the Onondaga limestone. The Onondaga averages 168 feet thick with the top of the chert section

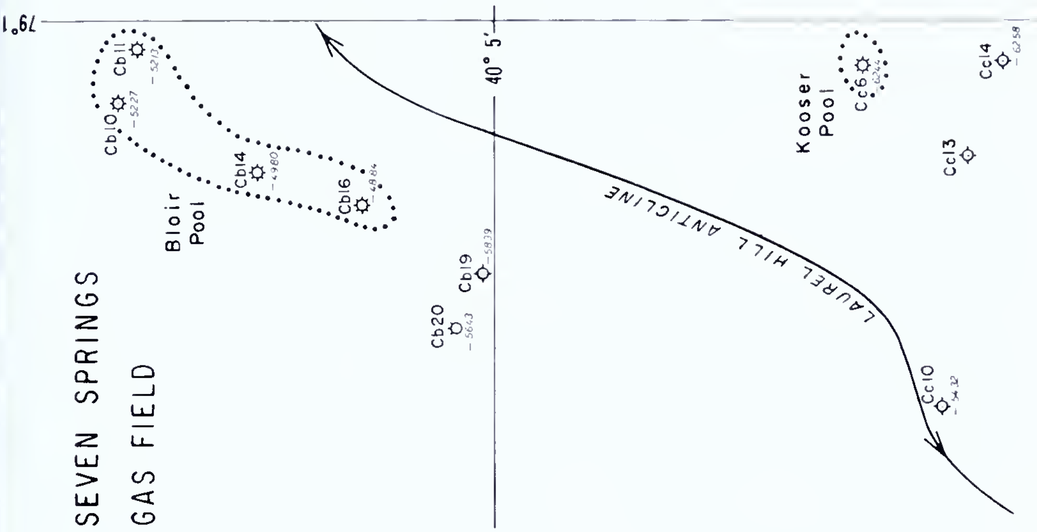
Table 6. Summarized records of deep wells in the Donegal quadrangle

Well and map reference		Operator	Date completed	Elevation	Tully	Onondaga	Oriskany	Helderberg	Total depth	Deepest formation tested	Result
William Piper #1	Ba6	Peoples Natural Gas Co.	8-17-49	2061	7475-7550	8128-8301 Top chert 8158. 124 MCF gas-8223-8229	8301-8360 Show of gas at 8309 & 8360	8360- Show of gas at 8469	8552	Oriskany	243 MCF gas from Onondaga and Oriskany after acidizing. R.P. 3875 p.s.i.
J. R. Frola #1	Ba7	do.	6-8-53	2146	7351-	8130- Chert 8140-	8289- Show of gas at 8298		8465	Oriskany	8 MCF gas after shot. Abandoned.
Fred Musnug #1	Ba9	do.	6-30-51	2100	7225-	7980- Chert 8003- gas	8150 Show of gas		8330	Oriskany	7,194 MCF gas after shot. R.P. 3675 p.s.i. in 24 hours in Onondaga.
Fred Musnug #2	Ba10	do.	6-3-55	2087	7850-	8548-	8740- Show of salt water		8773	Oriskany	Dry
A. J. Dotterway #1	Ba11	do.	3-26-53	2094		8249- Chert 8293-			8901	Onondaga	Dry
A. W. Kintz #1	Ba37	do.	6-14-54	2066					8555	Tully	Abandoned above Onondaga.
Benedictine Society #1	Ba20	do.	5-4-57	1883	6656-6730	7272- Chert 7288- Gas at 7315	7427-		7465	Oriskany	6,852 MCF gas after fracturing.
J. S. Mailey #1	Ba21	do.	9-13-56	1879	6633-	7233- Chert 7253- 162 MCF gas	7407-7473		7478	Oriskany	11,000 MCF gas after fracturing. R.P. 4100 p.s.i. in 48 hours Discovery well.
B. H. Smithley #1	Ba33	do.	3-18-57	2001	6740-6820	7332- Chert 7226-	7497-		7539	Oriskany	Gas at 7368, Initial open flow 2,564 MCF. RP. 3290 p.s.i. in 48 hours.
C. E. Schultz #1	Ba27	do.	9-5-57	1772	6590-	7207- Chert 7226-	7377-		7435	Oriskany	Gas at 7308. 6,154 MCF gas after fracturing. R.P. 3100 p.s.i. in 17 hours.
V. Schworer #1	Ba13	Keta Gas & Oil Co.	4-9-57	1570	7120-	7800- Chert 7837- S.W. at 7837			7877	Onondaga	Salt water rose 5000 ft. Abandoned.
H. E. Leighty #1	Ba28	Peoples Nat. Gas Co.	3-8-57	2129	7541-	8425- Chert 8480- 3000 ft. of			8679	Onondaga	Dry below Tully. Plugged back to 3100 ft. Sand, 3079-3097, gas at 3088, 170 MCF

M. I. Keck #1	Aa39	do.	9-13-57	1840	6834-6925	7455- Chert 7475- gas at 7490			7565	Onondaga	Initial open flow 11,365 MCF gas. R.P. 3290 p.s.i. in 48 hours. Not fractured.
Irah Keck #2	Aa40	do.	4-28-58	1887	6876-	7521- Chert 7545-	7702-7719		7722	Helderberg	583 MCF gas after fracturing. R.P. 2950 p.s.i. in 10 days.
J. H. Dent #1	Ab10	do.	5-9-58	1808	6860-	7404- Chert 7423- 348 MCF gas			7525	Onondaga	2,316 MCF gas after fracturing. R.P. 3075 p.s.i. in 48 hours.
N. A. Myers #1	Ab10	do.	5-29-58	1999	6982-7080	7584- Chert 7603-			7708	Onondaga	1,404 MCF gas after fracturing. R.P. 3025 p.s.i. in 24 hrs.
J. A. Cummings #1	Ab11	Felmont Oil Corp.	9-25-58	1905	6903-7310	7982-8005 Chert 8005-8119. Show gas & S.W.			8119	Onondaga	17 MCF gas 8019-8030, 1 bbl. S.W. per hr. 8050-8055 & 8058-8068. Abandoned.
J. S. Blair #3	Cb10	Peoples Nat. Gas Co.	9-18-59	2438	Hamilton 7035-	7665- Chert 7681-	7829-		7854	Oriskany	2,144 MCF gas after fracturing. R.P. 3185 p.s.i. in 24 hrs.
H. A. Byers #1	Cb11	Columbian Carbon Co.	10-6-59	2475	6573-	7688- Chert 7710- Gas show-7710-7720	7837-	7952-	8026	Helderberg	4,108 MCF after fracturing. R.P. 3400 p.s.i. in 24 hours.
J. S. Blair #2	Cb14	Peoples Nat. Gas Co.	3-5-59	2186	Hamilton 6530-	7166- Chert 7188-	7335-		7384	Oriskany	9,910 MCF gas after fracturing. R.P. 3270 p.s.i. in 24 hrs.
J. S. Blair #1	Cb16	do.	12-5-58	2685	Hamilton 6923-	7570- Chert 7606- 3000 MCF gas at 7685	7778-		7831	Oriskany	3,663 MCF gas natural. R.P. 3250 p.s.i. in 10 days. Discovery well.
J. R. Tinkey #1	Cb20	Felmont & Peoples	5-12-60	2434	Hamilton 7450-	8077- Chert 8099-			8201	Onondaga	10 MCF gas 8140. 2 bbls. S.W. per day.
Andrew Donitzen #1	Cb19	Mid-Atlantic Oil & Gas Co.	12-16-60	2592		Chert 8027-	8262-		8300	Oriskany	S.W. after fracturing.
Pa. Tract 75 #3	Cc6	Peoples Nat. Gas Co.	5-19-59	2196	Hamilton 7717-	8440- Chert 8460- Gas 8472-74			8477	Onondaga	10,932 MCF gas natural. R.P. 3460 p.s.i. in 10 days. Discovery well.
Pa. Tract 75 #1	Cc13	do.	6-21-58	2461					7936		Dry.
Pa. Tract #4	Cc14	do.	5-27-60	2632	Hamilton 7765-	8890- Chert 8915			9085	Oriskany	Dry.
Adolph Dupree #1	Cc10	Mid-Atlantic Oil & Gas Co.	10-22-54	2738		8170- Chert 8191	8355-		8477	Oriskany	Dry.



LYCIPPUS GAS FIELD



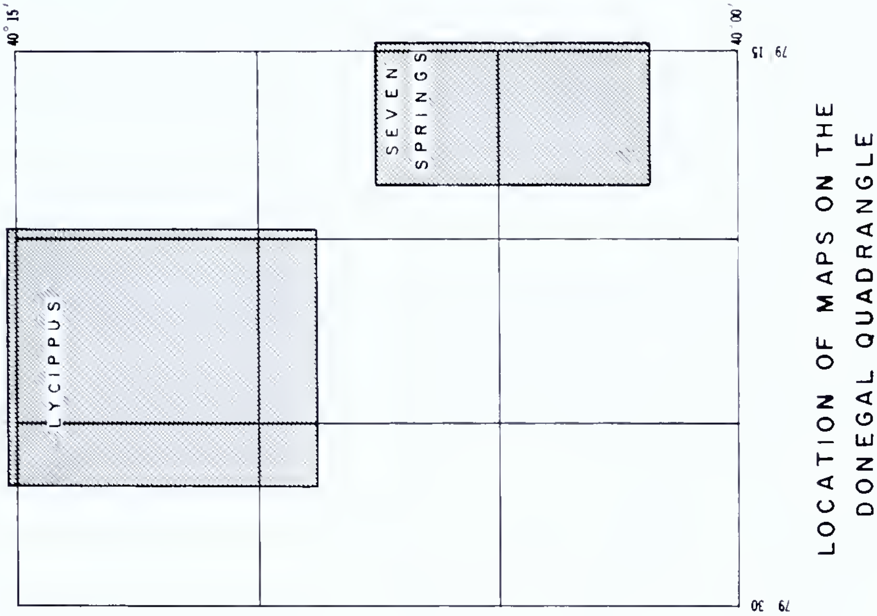


Figure 13. Gas fields and pools in the Donegal quadrangle.

being from 10 to 30 feet below the top of the limestone. The Oriskany sandstone, which lies below the Onondaga, has an average thickness of 76 feet.

Seismograph exploration and drilling on Chestnut Ridge and Laurel Hill anticlines has revealed complex subsurface faulting of great magnitude. The details of this exploration are classified as confidential by the companies involved.

The V. Schworer no. 1 well (Ba 13) was drilled by Keta Gas and Oil Company and the J. A. Cummings no. 1 well (Ab 11) was drilled by Felmont Oil Corporation. The remainder of the wells were drilled by Peoples Natural Gas Co.

Piper Pool

The Piper pool on the northeastern part of the Lycippus field is just east of the northeast-plunging axis of Chestnut Ridge anticline. Six wells have been drilled in this area, two of which were economically productive. William Piper no. 1 well (Ba 6), the discovery well (August 17, 1949), had a natural flow of 124 m.c.f. of gas from the Onondaga chert at a depth of 8223 feet, and a "show" of gas in the Oriskany at 8309 feet. After acidizing, the combined yield from the chert and the sandstone was 243 m.c.f. of gas at a reservoir pressure of 3875 p.s.i. Fred Musnug no. 1 well (Ba 9) was completed June 30, 1951 and found "shows" of gas in the Onondaga and Oriskany at depths of 8003 and 8150 feet respectively. After "shooting", 7,194 m.c.f. of gas was produced from the Onondaga at a reservoir pressure of 3675 p.s.i. in 24 hours.

Completion data on the four unproductive wells are as follows: The J. R. Frola no. 1 well (Ba 7) is located about midway between the Piper no. 1 and Musnug no. 1 wells. This well was completed June 8, 1953. It found a "show" of gas in the Oriskany at 8298 feet and yielded 8 m.c.f. of gas after "shooting"; the well was plugged and abandoned. The A. J. Dotterway no. 1 well (Ba 11), completed March 26, 1953 was drilled to the Onondaga at a total depth of 8901 feet and was dry. The A. W. Kintz no. 1 well (Ba 37) was completed June 14, 1954 and was abandoned above the Onondaga at a total depth of 8555 feet. Fred Musnug no. 2 well (Ba 10) was completed June 3, 1955 and found salt water in the Oriskany at a depth of 8740 feet.

A strike fault (Fig. 13) with a displacement of 585 feet is indicated between Musnug no. 1 well (Ba 9) on the upthrown side and Musnug no. 2 well (Ba 10) on the downthrown side. The distance between these wells is about 1500 feet. It could be said, therefore, that faulting at depth probably is accountable for the restrictive limits of production in the Piper pool.

It was reported from an authoritative source, that systematic seismograph exploration has revealed that complex structural conditions prevail at depth in the untested area extending about 2.5 miles along Chestnut Ridge anticline between the Piper and St. Boniface Chapel pools, and it appears therefore, that the area was not drilled because it was considered unfavorable for productive accumulation of gas.

St. Boniface Chapel pool

The St. Boniface Chapel pool in the southern part of the Lycippus field is narrow, and the productive trend has a known linear extent of 3.8 miles. It lies west of and parallel to the southwest-plunging axis of Chestnut Ridge anticline. The pool is also west of, and on the upthrown side of, a strike fault that has a displacement of 492 feet at the south and 861 feet at the north (Fig. 13). The trend of the pool is established in a series of 8 economically productive wells (Ba 20, 21, 33, 27, 30; Ab 7, 10; Aa 39) located in a nearly straight alignment, bearing N. 40° E., which conforms generally to the regional strike of the anticlinal axis. The top of the Onondaga limestone in these wells occurs at a relatively uniform position with respect to sea level. It descends rather regularly southwestward from minus 5331 feet at the northern part of the pool to minus 5596 feet at the southern part of the pool, a difference of 266 feet, which is approximately conformable to the regional plunge of the fold. It appears, therefore, that the zone wherein gas had accumulated was laterally unaffected by subsurface dislocation.

Discovery of the St. Boniface Chapel pool was made in Peoples Natural Gas Co.'s J. G. Mailey no. 1 well (Ba 21) which was completed October 13, 1956. The Onondaga chert had an initial open flow of 162 m.c.f. of gas at a depth of 7253 feet. After fracturing, the yield increased to 11,000 m.c.f. of gas at a reservoir pressure of 4,100 p.s.i. in 48 hours. M. L. Keck no. 1 (Aa 39), the largest productive well in the pool, had an initial natural flow from the Onondaga chert of 11,365 m.c.f. of gas with a reservoir pressure of 3290 p.s.i. in 48 hours. The chert is at a depth of 7490 feet. Completion data of the other wells drilled in the pool are given in Table 8.

Two outstep wells, both unproductive in the Onondaga were drilled on the down-thrown side of the inferred strike fault. The H. E. Leighty no. 1 well (Ba 28) found salt water in the Onondaga chert at a depth of 8480 feet. A small volume of gas had been encountered in a sand in the Upper Devonian (Second Bradford ?) from 3079 to 3097 feet. The well was plugged back to 3100 feet, and after the sand was fractured, it yielded 170 m.c.f. of gas at a reservoir pressure 920 p.s.i. in 40 hours. This is the only shallow sand gas production in the Donegal quadrangle. Felmont Oil Corporation drilled the J. A. Cummings no. 1 well (Ab 11) which had a show of gas and produced salt water from the Onondaga at a depth of 8005 feet.

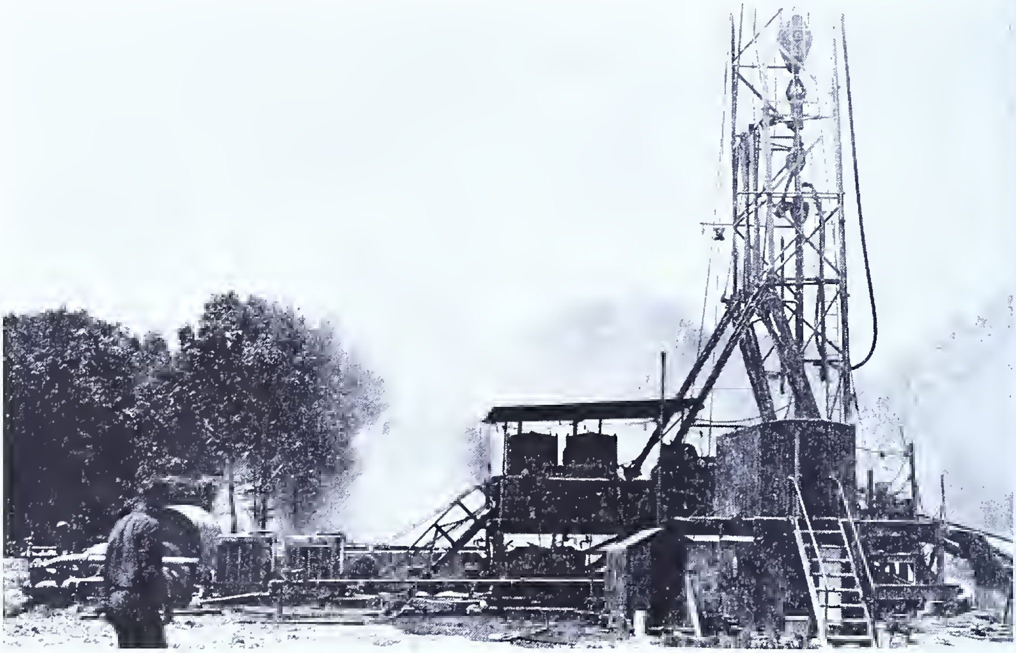


Figure 14. Rotary drilling for gas. The Leighty well of the Peoples Natural Gas Company south of St. Boniface Chapel (Ba 28).

The V. Schworer no. 1 well (Ba 13) was an off-structure wildcat location on the west limb of Chestnut Ridge, drilled by Keta Gas and Oil Company. Salt water from the Onondaga chert was encountered at a depth of 7837 feet and it rose to 5000 feet in the well.

Chestnut Ridge anticline south of Jacobs Creek has a linear extent of about 9 miles in the Donegal quadrangle, and the deep potential gas horizons remain to be tested. The subsurface structure has been systematically explored by seismograph, but the results are confidential.

Seven Springs Field

The Seven Springs gas field on Laurel Hill anticline (Fig. 13) includes the Blair pool on the west limb at the north and the Kooser pool on the east limb of the anticline at the south. Since the discovery of natural gas on Laurel Hill anticline in December, 1958, and up to May, 1960, ten wells have been drilled in the field, of which 5 produced large volumes of gas from the Onondaga chert section. The average depths of the wells is 7729 feet and their combined initial yield amounts to 30,758 m.c.f.

Discovery of gas in the Seven Springs field was made by Peoples Natural Gas Co.'s J. S. Blair no. 1 well (Cb 16) which was completed on December 5, 1958, and had a natural yield of 3,663 m.c.f. of gas from the Onondaga chert at a depth of 7607 feet; the reservoir pressure after 10 days gauged 3,250 p.s.i. J. S. Blair no. 2 well (Cb 14), an outstep three fourths of a mile to the north, was completed March 5, 1959. The chert was found at a depth of 7188 feet and, after fracturing, yielded 9,910 m.c.f. of gas with a reservoir pressure of 3270 p.s.i. after 24 hours.

The pool was extended farther to the north, when on September 18, 1959, the Blair no. 3 well (Cb 10) encountered the chert at a depth of 7681 feet and, after fracturing, yielded 2,144 m.c.f. of gas; the reservoir pressure after 24 hours gauged 3185 p.s.i. An offset location about 2,000 feet east of Blair no. 3 well was made by Columbian Carbon Company, and their H. A. Byers no. 1 well (Cb 11) was completed in the Onondaga chert at a depth of 7710 feet on November 6, 1959. After fracturing, the chert section yielded 4,108 m.c.f. of gas with a reservoir pressure of 3400 p.s.i. after 24 hours.

Two unsuccessful outstep wells were drilled south of the Blair pool. The J. R. Tinkey no. 1 well (Cb 20) was a joint venture by Felmont Oil Co. and Peoples Natural Gas Company. The well was completed May 12, 1960, and produced from the Onondaga chert 10 m.c.f. of gas and 2 bbls. of saltwater at a depth of 8140. Mid-Atlantic Oil and Gas Company's Andrew Donitzen no. 1 well (Cb 19) was completed in the Oriskany sandstone at a depth of 8300 feet on December 16, 1960, and produced saltwater after fracturing. Mid-Atlantic Oil and Gas Company's Adolph Dupree no. 1 well (Cc 10) located just east of the southwest plunging axis of Laurel Hill anticline, was the first test well in the Seven Springs field; it is located on the crest of the Laurel Hill anticline. The well was completed in the Oriskany on November 22, 1954, at a depth of 8477 feet. The chert and the sandstone were dry. A sample log of this well is presented on Page 21. Peoples Natural Gas Company's well no. 1 on Pa. tract 75, located on the east limb of Laurel Hill anticline (Cc 13), was completed June 21, 1958. Drilling was stopped above the Onondaga limestone at a total depth of 7936 feet.

The Kooser pool on the east limb of Laurel Hill anticline was discovered May 19, 1959, in the Peoples Natural Gas Company's well no. 3 on Pa. tract 75 (Cc 6). A natural flow of 10,933 m.c.f. of gas was found in the Onondaga chert at a depth of 8472 feet, the reservoir pressure was 3400 p.s.i. after 10 days. This is the deepest productive gas well in Pennsylvania (Wm. Lytle et al, 1959). Well no. 4 on Pa. tract 75 (Cc 14) was an outstep to the south. It was completed to the Oriskany sandstone, May 27, 1960. The chert and sandstone were dry.

The off-structure wells, or those drilled on the limbs of the anticline in the Seven Springs field, were probably located from studies of the subsurface structure as determined from the results of systematic seismograph exploration on Laurel Hill anticline.

Shallow Gas Sand Exploration

The "shallow" stratigraphic-trap type of gas sand in the Upper Devonian was tested in three widely separated localities in the Donegal quadrangle prior to discovery of deep gas, but commercial volumes of gas were not found until the H. E. Leighty deep test well located on the crest of Chestnut Ridge (Ba 28) produced gas from a sand questionably correlated with the Second Bradford (page 14). Following are summarized data on the shallow wells in the Donegal quadrangle:

The Anna Grimm well, located on the crest of Chestnut Ridge in Bullskin Township (Ab 30) is the first well known to have been drilled for gas in the quadrangle. The name of the owner of the well and the completion date are not known. Starting in the Homewood sandstone at an altitude of approximately 2030 feet, the well was stopped in the Upper Devonian at a total depth of 4108 feet. Water and a "show" of gas occurred in the Big Injun (Pocono) at a depth of 1010 feet; the top of the Catskill red beds is at a depth of 1410 feet.

Phillips Oil and Gas Company drilled the John Darr well located in the Ligonier syncline east of Pleasant Grove (Ca 18) and it was completed in 1931. This well started in the Conemaugh Formation at an altitude of about 1600 feet about 480 feet above the upper Freeport coal horizon. The top of the Catskill is at a depth of 2335 feet, and the well was finished 1875 feet below, at a total depth of 4200 feet. A "show" of gas was found in the Big Injun sand at a depth of 1956 feet. The well was plugged and abandoned.

Information was available on four shallow wells located within an area of about half a square mile on the west side of Chestnut Ridge east of Mammoth (Aa 22, 27, 29, 30). These wells were promoted by apparently small, independent operators unknown to the author, and the reason for the relatively close spacing of the locations is speculative.

The Mary Yonek well (Aa 29) was drilled by I. Tanner et al. Drilling began on August 4, 1942 and the well was completed November 11, 1942. Starting at an altitude of about 1200 feet, about 130 feet below the upper Freeport coal horizon, the well was drilled to a total depth of 2060 feet. A "show" of gas occurred in a sand at a depth of 2055 feet, 589 feet below the top of the Catskill. The well was abandoned but not plugged. The same operator drilled the Ezra Ankney well (Aa 30) which was completed June 6, 1944. This well was dry in the Big Injun sand at a total depth of 797. The casing was pulled and the hole was plugged.

The Barnesville Development Company drilled the Peter Hunter well (Aa 27) which was completed at a total depth of 2015 feet in February 1943. The well was started in the Conemaugh Formation at an altitude of about 1170 feet, about 90 feet above the horizon of the upper Freeport coal. A "show" of gas was encountered at a depth of 1956 in a sand 490 feet below the top of the Catskill red beds. The Joe Schick well (Aa 22) was a dry hole drilled by Fred Ferrari which was completed at a total depth of 2955 feet, April 1949. The well started in the Conemaugh Formation at an altitude of about 1270 feet, about 220 feet above the horizon of the upper Freeport coal. The top of the Catskill is at a depth of 1838 feet.

CLAY AND SHALE

Clay and shale deposits suitable for manufacture of various clay products are available in the Donegal quadrangle. These resources have not been developed commercially, and only minor exploratory tests have been made. The mineralogy and physical properties of clays and shales in southwestern Pennsylvania have been described by Leighton and Shaw (1932).

Plastic clays commonly underlie coal beds, and clay may occur where coal is lacking. The plastic clays are structureless, light to dark gray, and locally are moderately carbonaceous, but they are bleached white at weathered outcrops. Most of the plastic clays are free from impurities but some become increasingly silty downward, and at the bottom become fine-grained quartz sandstones. Underclays in the Pottsville and Allegheny Groups merit attention for manufacture of fire brick, buff face brick, and other ceramic products. Semiflint clays are locally associated with plastic underclays, but they have doubtful economic worth.

Abundant deposits of shale are widely distributed in the quadrangle, particularly in the Conemaugh Formation. Although the shales tend to be silty, some of them may serve for manufacture of red face brick.

Pottsville Clays

Mercer clay

The clay associated with the Mercer coal is noted for its excellent quality and persistently workable thickness of numerous localities in western Pennsylvania. Presence of Mercer clay is known from widely distributed partial exposures on Chestnut Ridge in the northern part of the Donegal quadrangle, but apparently good quality plastic clay is indicated and systematic prospecting may find workable deposits. Mercer clay was noted at the following selected localities: About 5 feet of gray, plastic clay was exposed in a test pit north of Ridge School (Ba 2). At least 10 feet of plastic clay is exposed in the bank of a small stream northwest of locality (Ba 12) and west of B. M. 1321 (the outcrop could not be accurately located on the map). The Mercer coal is overlain by about 15 feet of plastic clay, and underclay is indicated in a test pit north of Rodney (Ab 9).

Mercer clay is indicated under the coal at the following localities on the west limb of Laurel Hill: South of Weaver Mill (Cb 5) and east of Roaring Run (Cc 1, 2).

Brookville clay

Plastic clay appears to be everywhere present under the Brookville coal along its extensive outcrop on the limbs and crest of Chestnut Ridge. Accurate measurement of the bed was nowhere obtainable, but the appearance of the weathered outcrop suggests that it probably is a high grade workable deposit of plastic clay. The Brookville underclay in this area is generally characterized by relatively abundant, irregularly shaped nodules of limonite occurring on top of the clay bed. Following are selected localities on Chestnut Ridge where weathered outcrops of the Brookville underclay could be examined: North of Ridge School (Ba 3), west of Ridge School (Ba 17), west of Laurel Run School (Ba 29, 31), north of Alice (Ab 6; Ac 38), south and west of St. Boniface Chapel (Ba 22, 14) and west of Acme (Ab 19, 22).

Allegheny Clays

Lower Kittanning clay

Clay, from about 4 to 12 feet thick is reportedly everywhere under the lower Kittanning coal in the extensive mines about Melcroft and Indian Head. Core drill holes that tested the lower Kittanning outside of the mined areas (Plate 2) proved presence of underclay, but the full thickness of the clay bed was not penetrated. Lower Kittanning clay was exposed in the railroad cut south of Indian Head (Hickok and Moyer, 1940) where it consisted of 6 feet of plastic clay with a 1-foot layer of flint clay near the top.

Good quality plastic clay is indicated under the lower Kittanning coal at the following localities elsewhere in the Donegal quadrangle: test pit, south of St. Boniface Chapel (Ba 23), outcrop just east of locality Ab 8, strip mines north of Buchanan (Ac 6) and west of Rasler Run (Ac 47, 48).

Middle Kittanning clay

Clay under the middle Kittanning coal was exposed in the high wall of an extensive strip mine on the lower Kittanning coal west of Rasler Run (Ac 47, 48) but it was inaccessible for examination. A bed of low grade clay, 7 feet thick underlies the middle Kittanning coal where it crops out in a cut bank west of Jockey Knob (Ac 24). Clay deposits occur locally under the middle Kittanning coal in the core drill tested area about Melcroft (Plate 2).

Upper Kittanning clay

Fragments of flint clay occurring at the approximate stratigraphic horizon of the upper Kittanning coal, were found in the material excavated from long abandoned pits east of Jones Mill (Bb 23). Information about these working could not be obtained. South of the above locality and east of Roaring Run (Bc 7), the upper Kittanning flint clay was worked in a series of pits. The clay is presently concealed, but it is reportedly from 4 to 6 feet thick and of excellent quality. Local deposits of clay occurring at irregular positions in the interval between the middle and upper Kittanning coal horizons are indicated in the core drill holes on Plate 2. Section 5 shows about 15 feet of alternating beds of limestone and clay, underlain by about 10 feet of flint clay.

Lower Freeport and upper Freeport clays

All that could be learned about the underclays of the Freeport coal beds is revealed in the sections of core drill holes on Plate 2, which shows some relatively thick local deposits of clay under these coals. On the Turnpike north of Franklin (Cb 8), the upper Freeport coal is underlain by a few feet of clay which contains nodules of limestone in the lower part. A clayey zone 15 feet thick containing abundant limonite nodules is under the upper Freeport coal where it is exposed on the Turnpike north of Laurelville (Ab 5).

Bolivar flint clay

The Bolivar flint clay underlies the upper Freeport limestone at the type locality near Bolivar on the Conemaugh River in the New Florence quadrangle (Shaffner, 1958). The only known exposure of the Bolivar flint clay in the Donegal quadrangle is on the Turnpike north of Franklin (Cb 8) where it is a 4-foot bed of gray semiflint clay occurring below nodular upper Freeport limestone. The clay at this locality is of questionable economic value because it contains lenses and angular fragments of siltstone. Weathered-out, angular fragments of flint clay mark the outcrop of the Bolivar clay at a few localities on the west side of the Ligonier syncline near Acme.

Flint clay is not indicated at the Bolivar horizon in the records of core drill holes about Melcroft (Plate 2).

Shale Deposits

The Mauch Chunk Formation which crops out on Laurel Hill and Chestnut Ridge, is composed largely of red shales with subordinate siltstones and sandstones. A rather thick section of silty red shale lies just above the Greenbrier limestone. Shales in the Pottsville Group are minor constituents intercalated in thick-bedded sandstones. As may be seen on Plate 2, thick deposits of shales occur locally and at various stratigraphic positions in the Allegheny Group. Roof shales of the coal beds are generally carbonaceous and dark to medium gray and become lighter and less carbonaceous upward.

The Conemaugh Formation which covers very large areas in the Ligonier and Latrobe synclines, contains an abundance of gray, green-gray and buff shales that probably would be found suitable for manufacture of building brick. Comparable raw material in the Conemaugh has been used for similar products in southwestern Fayette County (Hickok and Moyer, 1940). Carbonaceous shales, about 15 feet thick overlie the Brush Creek and lower Bakerstown coals have been worked in "borrow" pits at a few places and used for surfacing tertiary township roads. The Brush Creek coal is underlain by 12 feet of clay shale where it is exposed in the Mt. Joy Cut on the Turnpike (Ab 4).

LIMESTONE

A discussion of the uses of limestone and the chemical and physical requirements defining specific uses is too extensive to be included in this report. For such information the reader is referred to the report "Limestones of Pennsylvania" (Miller, 1934).

The character and distribution of the freshwater limestone lentils occurring below many of the coal beds in the Allegheny, Conemaugh, and Monongahela strata have been adequately described previously under the heading "Surface Rocks". These argillaceous limestones have negligible economic value. They have been quarried in the past in small pits by the landowners, and were burned in pyramidal heaps of alternate layers of limestone and coal. Wood, placed at the bottom was ignited and the pile was allowed to burn itself out; the residual mass was scattered over the fields. The resultant lime was far from pure, and large pieces of limestone were only partly calcined. Superior commercial lime has almost entirely replaced this primative method of obtaining agricultural lime; and the limestone beds in the numerous abandoned pits are nearly everywhere concealed by soil.

Loyalhanna limestone

The Loyalhanna limestone which occurs between the Pocono sandstone and the Mauch Chunk red beds, has such a large siliceous content that it may just as properly be called a calcareous sandstone. It has, however, been grouped with the limestones in the literature, and is so referred to here. The trade name for the Loyalhanna among the quarrymen is the "blue rock". The physical characteristics and a summary of the mineralogy of the Loyalhanna are described on page 24.

This commercially valuable rock has long undergone large-scale quarrying and drift-mining at numerous places along its extensive outcrop on Laurel Hill and Chestnut Ridge in Fayette, Somerset, and Westmoreland counties. Very great tonnages have been produced for use as railroad ballast, base course, and concrete aggregate for construction of modern highways. Paving stones, knows as "Belgian blocks", and dimension stones were also produced. Because of its massive character, the rock, when blasted, breaks out into large blocks which are readily split into desirable sizes; the fracture is subconchoidal.

Available reserves of Loyalhanna in the Donegal quadrangle are practically unlimited. The irregular, linear outcrop forms a narrow band in the marginal forested upland on Laurel Hill, and the crop line has a total extent of roughly 50 miles. The overlying Mauch Chunk is composed of relatively soft material that could be removed with a minimum of preparation by blasting, but the thickness of the overburden increases rapidly in from the outcrop in the steep-sided ravines; spoiling of the overburden would be a minor problem. A quarry located on the east side of Laurel Hill on Pa. Route 31 (Cc 4) and operated by the Somerset Lime Co., is presently (1960) producing crushed Loyalhanna limestone. The maximum thickness of the bed in the quarry is 59 feet, which is the only accurate measurement of the Loyalhanna obtainable on Laurel Hill.

The Loyalhanna is exposed in four inliers in steep-sided ravines on the west side of Chestnut Ridge. Idemiller Enterprises, Inc. operate a large quarry on the limestone in the north-central part of the quadrangle (Ba 12). The operation requires 25 employees and the plant consists of one primary jaw crusher and four gyratory crushers; electric power is generated by diesel engines at the site. The average daily production is 1,000 tons and the rock is screened into sizes up to four inches. The maximum thickness of the Loyalhanna in the quarry is 69 feet.

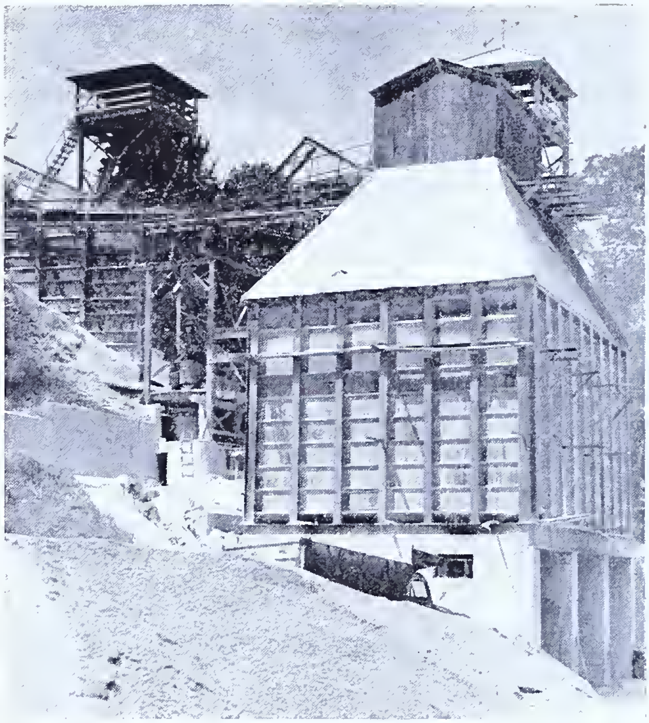


Figure 15. Crushing and sizing plant at the Idemiller quarry (Ba 12).

Analyses of the Loyalhanna limestone in the Donegal quadrangle were not available. Chemical and physical analyses have been made of the Loyalhanna in Fayette County (Hickok and Moyer, 1940) and the minimum, maximum, and average of seven chemical and twelve physical analyses are assembled in tables below. The general physical characteristics of the Loyalhanna have a wide regional similarity, and it could therefore be expected that the chemical and physical properties of the Loyalhanna in the Donegal quadrangle will fall within these maximum and minimum ranges.

Chemical analyses of Loyalhanna limestone

	Minimum	*Maximum*	*Average*
SiO_2	21.46	50.95	39.29
Al_2O_3	1.96	3.71	3.04
Fe_2O_3	.60	1.56	1.15
$CaCO_3$	41.73	74.82	54.31
$MgCO_3$	.56	2.80	1.0

Physical analyses of Loyalhanna Limestone

	Minimum	*Maximum*	*Average*
Sp. gr.	2.63	2.69	2.68
Weight lbs./cu. ft.	164.1	174.2	167.4
Adsorption	.22	1.65	.46
Percent wear	2.2	3.9	2.7
French coefficient of wear	10.2	18.2	15.1
Toughness	8	22	14

Greenbrier limestone

The Greenbrier marine limestone occurring in the lower part of the Mauch Chunk Formation, had local importance as a source of agricultural lime. The thicker beds in the deposit, when calcined, furnished a relatively good quality lime and are hard enough for some structural uses. Farmers, singly and jointly worked the limestone in open pits and drift-mines at various places along its extensive outcrop on Laurel Hill and Chestnut Ridge (Plate 1). The more convenient commercially prepared lime from distant places has now almost completely replaced the local product, but should there be a demand for this type of rock created by some technological development in the future, it would be available in almost inexhaustible supply.

Being soluble and easily weathered, the Greenbrier is concealed by residual soil and is therefore difficult to find, but as indicated by numerous long abandoned pits and drifts, the limestone is believed to be continuously present along its extensive outcrop (approximately 50 miles) on Laurel Hill (Plate 1). Although it was nowhere found fully exposed, confirmed reports indicate that it consists of thick beds of hard limestone from 5 to 7 feet thick and burns to good quality lime.

On Chestnut Ridge the outcrop of the Greenbrier is confined to the inliers of Mississippian rocks on the west limb of the anticline north of St. Boniface Chapel, on the Turnpike along Jacobs Creek, Green Lick Run, Mounts Run, and west of Clinton. Continuity of the limestone in Chestnut Ridge north of Jacobs Creek is inferred from drillers logs of gas wells. Starting at the north-central part of the quadrangle, the log of the Piper no. 1 well shows 9 feet of Greenbrier limestone and it thickens progressively southwestward to where it is exposed on the Turnpike (Ab 13) where it is 24 feet thick (see section, page 28.) This, incidentally, is an excellent fossil collecting locality, but is at an extremely dangerous place because the berm is narrow and the side cut is nearly vertical. The Greenbrier limestone had been worked at a few places southwest from Jacobs Creek but its thickness is unknown.

Analyses of the Greenbrier limestone from the Donegal quadrangle are unknown. The tables below show the ranges in chemical and physical properties of the Greenbrier in southern and southwestern Fayette County (Hickok and Moyer, 1940) and it would be reasonable to assume that the chemical and physical properties of the Greenbrier limestone in the Donegal quadrangle would fall somewhere within those limits.

Range in chemical properties of Greenbrier Limestone

	Maximum	*Minimum*	*Average*
SiO^2	14.63	6.38	10.55
Al^2O_3	4.38	1.79	3.28
Fe_2O_3	2.07	1.31	1.65
$CaCO_3$	85.15	75.27	79.98
$MgCO_3$	2.73	1.62	2.47

Range in physical properties of Greenbrier Limestone

	Maximum	*Minimum*	*Average*
Sp. gr.	2.73	2.66	2.69
Weight lbs./cu.ft.	170.5	165.7	168.3
Adsorption	0.72	0.10	0.41
Percent wear	5.6	1.9	4.0
French coefficient of wear	21.0	7.1	11.9
Toughness	13	5	9

SANDSTONE

Sandstones occur at frequent intervals in the section of Mississippian and Pennsylvanian strata in the Donegal quadrangle (see composite stratigraphic section on Plate 1). The character and distribution of these sandstones have been described in the foregoing part of this report under the heading "Surface Rocks".

Sandstones suitable for various uses are abundant and widely distributed in the quadrangle. They have been used for local domestic masonry and road metal. Very little sandstone had to be quarried because loose blocks or float in the fields and wood lots (field stone) were conveniently available. Some blocks are massive enough to be split into large sizes with relatively smooth surfaces for facing material of durable quality. Sandstone as building material is now generally replaced by concrete, cinder block, and brick.

Mississippian and Pennsylvanian sandstones occurring conveniently near large centers of population have been exploited commercially, and they have been found to be chemically and/or physically suitable for a variety of products, such as glass, sand, silica refractories, structural stone, base course stone for road construction, and miscellaneous uses, including molding sand and sand for blasting. The utilization and essential chemical and/or physical qualities of sandstones for specific uses is too extensive a subject to be included here. For such information, the reader is referred to the geologic report of Fayette County by Hickok and Moyer (1940).

Although sandstones for general purposes are nearly everywhere available in the Donegal quadrangle, the better-grade stone occurs in the Pottsville Group which is exposed over large areas on Laurel Hill and Chestnut Ridge. Being generally hard, durable, and massive, Pottsville sandstones form cliffs on the mountain spurs where sandstone blocks of sizable dimension have been weathered-out mechanically along joint planes leaving piles of rubble at the foot of the cliffs and talus on the slopes below. Large quantities of naturally quarried sandstone (mountain stone) are therefore readily available. Quarrying of Pottsville sandstones is facilitated by two irregularly spaced major joint systems intersecting at nearly right angles, and they are also at nearly right angles to the planes of bedding.

The Homewood sandstone at the top of the Pottsville not only is well suited for various structural uses, but, being commonly composed almost completely of quartz grains cemented by silica, also has the aspects of glass and silica-refractories sand. The Homewood sandstone has been used successfully for manufacture of these products elsewhere in Westmoreland (Fettke, 1919) and Fayette Counties (Hickok and Moyer, 1940). In recent years, however, the glass industry has narrowed the percentage allowable of impurities. In 1959, the Union Mining Company was erecting a plant on Chestnut Ridge in the central northern part of the quadrangle (Ba 5) to produce silica sand from the Homewood. The Homewood is usually strongly cemented and resistant, but at some places is weakly cemented and has weathered to sand. Sand was quarried from friable Homewood on Chestnut Ridge northwest of Buchanan (Ac 2).

Connoquenessing sandstone beds in the lower part of the Pottsville although generally massive and durable, tend to be impure and micaceous, and are coarser grained than the Homewood. Secondary limonite is commonly present in the joints and bedding planes, as is concretionary limonite in the bed.

A sandstone (siltstone) about 10 to 15 feet thick occurring about 15 feet below the unconformity at the top of the Mauch Chunk Formation merits attention for flagstone. The rock is fine-grained, greenish-gray, thin-bedded to flaggy, cross laminated in parts, and contains abundant mica flakes. It is well exposed on the west limb of Chestnut Ridge where a location was graded for a drilling rig (Ba 27), and partly exposed on the east limb of Laurel Hill west of Center Church (Cc 18). As indicated by numerous partial exposures this member appears to have a wide regional distribution in the Donegal quadrangle. It is also persistent in the New Florence quadrangle (Shaffner, 1958) where it is quarried on Laurel Hill and yields excellent flagstone.

IRON DEPOSITS

The iron ore industry was active from near the end of the 18th Century to late in the 19th Century in Fayette and Westmoreland Counties. The industry reached its height at the time of the Second Pennsylvania Geological Survey. A history of the old mines, furnaces, and description of the ore beds is given by J. J. Stevenson in his reports KK and KKK, 1877 and 1878. A relatively recent summary by Hickok and Moyer (1940) of the iron industry in Fayette County, has corrected errors in former correlations of the ore-bearing horizons.

The iron ores are generally thin sedimentary deposits; they consist mainly of carbonate which has been oxidized to limonite or brown iron ore along the outcrop. Iron carbonate (siderite) occurs as scattered egg-shaped concretions embedded in clay or shale; they are particularly common in the roof shales of some of the coal beds. Limestones, locally and in parts have been replaced by iron carbonate and their weathered outcrops are marked by irregularly shaped nodules of limonite. Hematite nodules up to about the size of walnuts occur sparingly and locally in the red beds of the Conemaugh and Mauch Chunk Formations.

Iron mining, if any, within the Donegal quadrangle is not recorded. Old prospect pits in the Mauch Chunk red beds are reported on Chestnut Ridge just south of Jacobs Creek and the Turnpike, but they were not found when the locality was recently investigated. The site of Fountain furnace of unknown vintage, is marked by its ruins on Camp Run just east of Locality Cb 17. This is the only iron furnace on record in the area, and the ore used in it was obtained from a bog nearby along Indian Creek.

Although the iron deposits in the Pennsylvanian strata were important sources of the ore in the past, they do not have economic value at present or in the foreseeable future. However, some of them are of mineralogical interest and the following horizons and localities are suggested for collecting. Iron carbonate concretions (siderite) are fairly abundant in the roof shales of the Brookville coal in a small strip mine west of Ridge School (Ba 17). Fragments of limonite from the top of the underclay of the Brookville coal are very abundant where a location was graded for a gas well rig west of St. Boniface Chapel (Bc 14).

WATER RESOURCES

The area covered by the Donegal quadrangle is included in a published groundwater investigation (Piper, 1933) which gives detailed descriptions on such subjects as water-bearing properties of the various rock types, chemical character of ground water, the relationship of ground water to topography and geologic structure, and various other technical data. These subjects are too expansive to be included in this report, but certain essential ones are briefly summarized below.

The Donegal quadrangle is topographically and structurally favorable for a wide range in conditions for occurrence of ground water. Because of the relatively high topographic relief and the attitude of the strata, thick sections of permeable beds of Pennsylvanian and Mississippian sediments crop out along drainage lines in the synclinal valleys and on the flanks of anticlinal mountains where they are recharged by meteoric water.

Nearly all of the named units in the composite stratigraphic section shown at the left on Plate 1 are known to contain variable quantities of water where they are not too deeply buried. Among those aquifers, the sandstones commonly are the major sources of ground water, and a water-bearing sandstone could likely be found in the zone of saturation in many places. The approximate depth to any given potential aquifer can be determined by its stratigraphic position with respect to the horizon of the Upper Freeport coal, which is the structure datum horizon on the geologic map.

As a general rule, appreciable quantities of fresh water are not encountered at depths of more than 300 feet from the surface, and the larger yields are encountered between 100 and 200 feet. The logs of wells drilled for natural gas indicate that connate salt water occurs at depths ranging between 800 and 1000 feet.

There are no sizable industries or institutions in the quadrangle using large quantities of water. The boroughs and small communities are supplied with water by individually or community-owned wells or with surface water from small reservoirs. In the rural areas, water is obtained mostly from drilled wells, but some farms still obtain water from dug wells and springs. Small, domestic quantities of water can be obtained nearly anywhere, the depth to the water being greater on hilltops than in valley bottoms. Large supplies for industrial or public use are less easily found. Exploration for large water supplies requires a knowledge not only of the rock types anticipated in drilling, but also of the geologic structure and the effect it will have on the storage capacity of the aquifer. Adequate storage capacity must be obtained to assure that large yields will be continually available through the years and through dry seasons. Areas in which inadequate storage capacity in an aquifer may present a problem are in the centers of the anticlines and at high elevations on

Table 7. Water data in the Donegal quadrangle

Well locations are shown in Figure 16

Well No.	Township	Well owner	Date completed	Altitude Feet	Topographical situation	Depth of well Feet	Diameter of casing Inches	Length of casing Feet	Depth to bedrock Feet	Depth to water-bearing zone Feet	Type of water-bearing rock	Geological horizon	Static Water level Feet	Yield g.p.m.	Use
1	Unity	O. M. Deibler		1010	Valley	60		8		40	Shale	Connellsville		5	Domestic
2	Mt. Pleasant	Harry Fisher		1140	Hilltop	50		20		45	Limestone		25	½	Do
3	Do	Newell		1210	Hilltop	100		20		95	Limestone			5	Do
4	Do	Ira Reese	8-2-59	1120	Hillside	60	6¼	20		53	Shale		17	5	Do
5	Do	Ridgeview School		1290	Hillside	48		20			Sandstone		17	5	Do
6	Do	John Mazur	5-26-58	1500	Hillside	85	6¼	21	20	80	Shale	Wellersburg		4	Do
7	Do	Mike Konacina	7-20-57	1470	Hillside	125	6¼	12	12	100	Shale	Saltsburg	70	5	Do
8	Do	Lola Keck	1-7-60	1190	Valley	120	6¼	100	8	115	Shale	L. Bakerstown	9	30	Do
9	Do	Ray Washington	5-20-58	1400	Hillside	70	6¼	12	12	65	Sandstone	Buffalo	3	4	Do
10	Do	Clair Wilkins	7-9-59	1250	Valley	27	6¼	27	27	21	Sand & gravel		3	10	Do
11	Do	Rodman School		1360	Hillside	67				67	Shale	Brush Creek	23	5	Do
12	Do	George Traynor	10-8-58	1470	Hillside	42	6¼	31	28	39	Sandstone	Conoquenessing			Do
13	Do	Harry Albert		1900	Hillside	30				29	Sandstone	Butler	23	5	Do
14	Do	Adrian Hoymen	9-11-57	1810	Hillside	35	6¼	15	15	35	Shale	Freeport	12	10	Do
15	Do	James McClain	8-30-57	1760	Valley	40	6¼	24	23	33	Sandstone	U.Worthington	22	10	Do
16	Do	James Thomas	5-25-59	1250	Valley	20	5⅝	20	20	10	Sand & gravel		20	4	Do
17	Do	Jesse Slater	6-2-58	1160	Valley	26	6¼	26		23	Shale	M. Kittanning	3	4	Do
18	Do	Robert Ashton	2-24-59	1850	Hilltop	95	6¼	8	2	85	Shale	Mercer	40	5	Do
19	Do	Robert Buono	10-2-59	2000	Hilltop	100	6¼	18	45	80	Shale	Mercer	60	20	Do
20	Bullskin	Mt. Zion Church		1985	Hilltop	62		18		62	Sandstone	L.Worthington	31		Do
21	Saltlick	Melcroft Coal Co.		1425	Valley	58		25		46	Sandtsone	Conoquenessing	12	5	Do
22	Do	Sam Calp		1425	Valley	26					Sand & gravel		20		Do
23	Donegal	J. M. Bollinger	5-23-59	2120	Valley	27	5⅝	27	27	15	Sand & gravel		5	5	Do

26	Do	Homer Bittern	8-26-57	1520	Valley	68	6	26		52	Sandstone	Freeport			Do
27	Do	William Tinkey	6-24-57	1580	Valley	72	6	26		61	Sandstone	Butler			Do
28	Do	Jack Kalp	5-24-57	1720	Hillside	96	6	23		83	Sandstone	Buffalo			Do
29	Do	Bill May	6-1-57	1720	Hillside	132	6	19½		119	Sandstone	Buffalo			Do
30	Do	Daniel Neiderhise		1775	Hillside	40		8		37	Sandstone	L. Saltsburg	18		Do
31	Do	American Legion	9-4-57	1820	Hilltop	163	6	23		148	Sandstone	Buffalo			Do
32	Do	Richard Clark		1730	Hillside	90	6	26		80	Sandstone	Buffalo			Do
33	Do	Robert Hauger	7-2-57	1840	Hilltop	90	6	90		80½	Sandstone	L. Saltsburg			Do
34	Do	Ted Monticues	6-8-57	1860	Hilltop	154	8	20		140	Sandstone	Buffalo			Do
35	Do	Oliver Crimebrook	8-20-57	1860	Hilltop	96	6	30½		85	Sandstone	L. Saltsburg			Do
36	Do	Joseph Kunkle	10-14-57	1820	Hilltop	110	6	21		95	Sandstone	L. Saltsburg			Do
37	Do	Joe Koryen	11-22-57	1830	Hilltop	110	6	30½		98	Sandstone	L. Saltsburg			Do
38	Do	Alvine Bittner	9-18-57	1510	Valley	66	6	26		55	Sandstone	Freeport			Do
39	Do	Amato Daquilante	6-27-59	1860	Hillside	38	6¼	23	22	33	Shale	Mahoning		10	Do
40	Do	Do	6-6-58	1830	Hillside	44	6¼	18	18	36	Shale	Mahoning	44	10	Do
41	Do	Mary Hauger	7-23-58	1730	Hillside	105	6¼	41	40	100	Limestone	Woods Run	90	20	Do
42	Do	Alex Douglas	9-12-57	1790	Hilltop	64	6	22		55	Sandstone	Grafton			Do
43	Do	W. J. Turley	6-25-59	1790	Hilltop	68	6	19	4	55	Shale	Mahoning			Do
44	Cook	George Davis	8-3-57	1880	Hillside	80	6¼	20	20	75	Shale	Freeport	45	8	Do
45	Do	James Bell	8-2-57	1560	Hilltop	165	6¼	20	20	85	Shale	Buffalo	60	3	Do
46	Do	Beckwith Co.	7-1-57	1400	Valley	70	6¼	23	22	65	Shale	Freeport	31	20	Do
47	Do	S.W. Field Research	11-22-57	1300	Valley	200	6¼	51	19	142	Shale	M. Kittanning		4½	Do
48	Do	Byron Neiderhiser	1-23-58	1590	Hilltop	79	6¼	20	16	47	Sandstone	Morgantown	20		Do
49	Do	Robert Terza	8-23-58	1220	Valley	55	6¼	31	30	40	Sandstone	Buffalo			Do
50	Ligonier	Laurence Cooper	1-4-58	1550	Hilltop	70	6¼	15	14	55	Shale	Grafton	70	8	Do
51	Do	Ligonier Country Club		1490	Hilltop	180		20		125	Shale	Ames	80	20	Do
52	Do	John McKlween	12-22-57	1420	Hilltop	104	8	15	14	95	Sandstone	Morgantown	55	20	Do

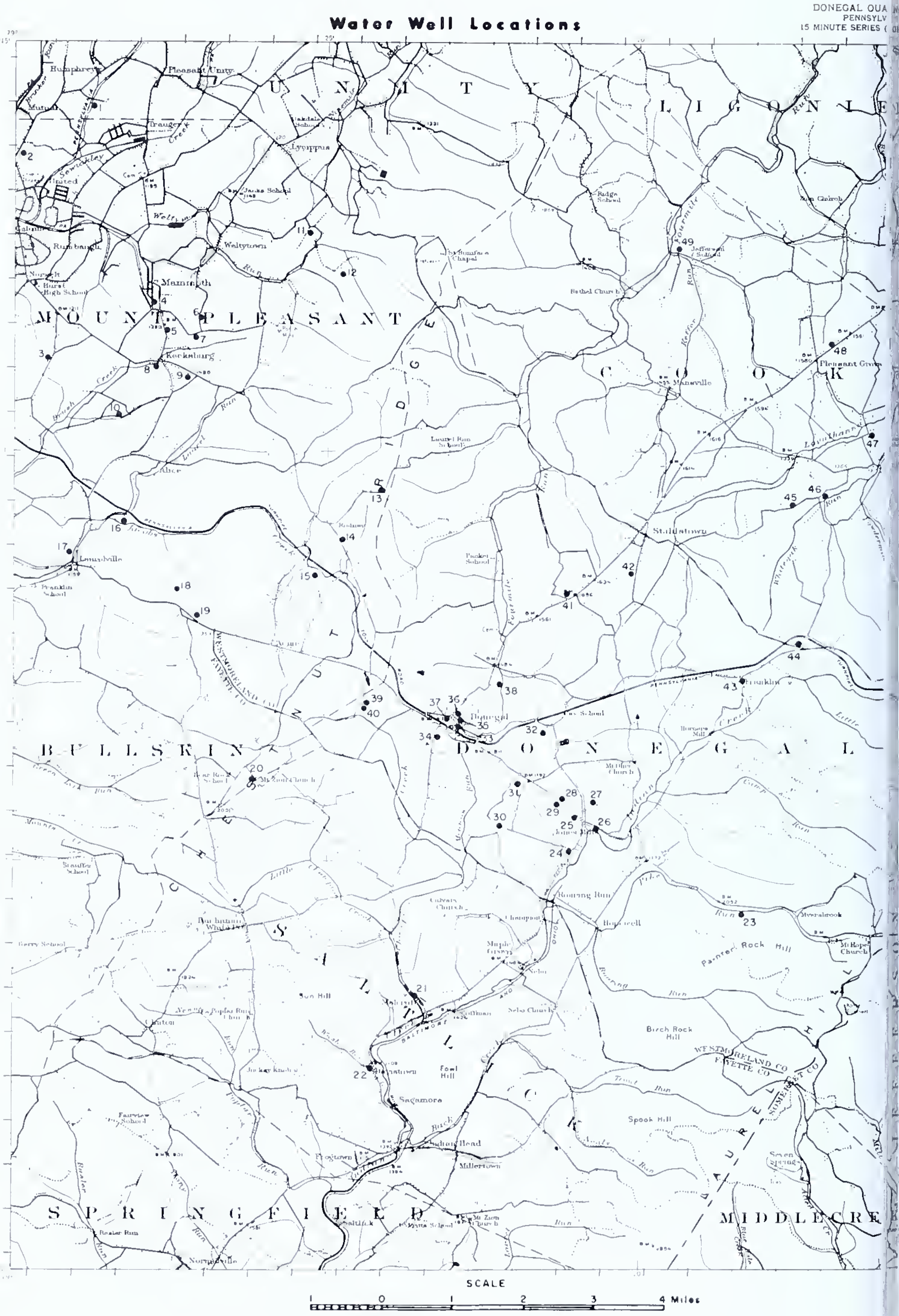


Figure 16. Map showing location of water wells recorded in Table 7.

the flanks of the anticlines. As a rule, wells drilled in the synclinal areas should encounter aquifers with adequate storage capacity; water in these areas would also be expected to be under an artesian head. In such wells, water would be expected to rise in the wells and in some cases to flow at the surface. It is recommended that individuals, companies, or municipalities seeking large water supplies enlist the aid of a professional geologist to evaluate the factors controlling large water yields within this area.

Available data on typical domestic water wells in the Donegal quadrangle are given in Table 7. Locations of the wells described are shown in Figure 16.

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APPENDIX I

GLOSSARY

Because some words in this report may not be familiar, the following definitions are given:

Anticline. An upfold or arch in the rocks.

Aquifer. A formation, group of formations, or part of a formation that is water-bearing.

Areal geology. Distribution, position and form of the areas of the earth's surface occupied by different sorts of rocks.

Argillaceous. Rocks or substances composed of clay, or having a notable proportion of clay in their composition.

Blossom". The oxidized or decomposed outcrop of a coal bed.

Cleat. Main set of joints along which coal breaks out in mining.

Conchoidal. To break with concave or convex surfaces.

Concretion. A mass of mineral matter in a rock produced from aqueous solution.

Cyclothem. A series of beds deposited during a single sedimentary cycle of the type that prevailed during the Pennsylvanian period.

Dendritic. Branching tree-like form.

Dimension stone. Stones that are quarried of required dimensions.

Dip. The angle at which beds or strata are inclined from the horizontal.

Drag fold. Smaller folds produced by the shearing stresses set up within a fold by the relative movements of beds along bedding planes.

Fault. A break or shear on which there has been an observable displacement of the two parts of the mass parallel to the plane of the break. Dip. A fault whose strike is approximately at right angles to the strike of the strata. Strike. A fault whose strike is parallel to the strike of the strata.

Fauna. The assemblage of the animal forms living in a given place at a given time (modern fossil).

Flint clay. A hard, blocky, non-plastic clay that breaks with a smooth conchoidal fracture and sharp edges.

Fusain. The ingredient of banded coal which occurs in lenses or lenticular bands, and displays a typical fibrous structure similar to charcoal.

Graywacke. A sandstone composed of 33 percent or more of easily destroyed minerals and rock fragments derived by rapid disintegration of basic igneous rocks, slates and dark colored rocks.

Incompetent beds. Not combining sufficient firmness and flexibility to transmit a thrust and to lift a load by bending.

Joint. A parting place which separates or tends to separate two parts of a once continuous block.

Megascopic. Observations made on minerals and rocks by means of the naked eye or pocket-lens, but not with a microscope.

Nodule. A small roundish lump of mineral or earth.

Oolites. Round grains like roe of fish.

Plasticity. The property of a substance whereby it can be permanently deformed without rupture.

Road metal. Rock suitable for surfacing and for foundations for roadways.

Slickensides. Polished and grooved surfaces caused by one mass of rock sliding past another as happens in faulting.

Strike. The trace of the dipping plane on the horizontal. The strike is at right angles to the dip.

"Sulphur". Coal miners term for pyrite.

Syncline. A trough; a structurally low point toward which the rocks dip.

Unconformity. An erosional break in the continuity of sedimentation.

Water table. The upper surface of a zone of saturation.

APPENDIX II

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	7	Outcrop, lower Bakerstown coal	42
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	3	Abandoned strip mine, lower Kittanning coal	70
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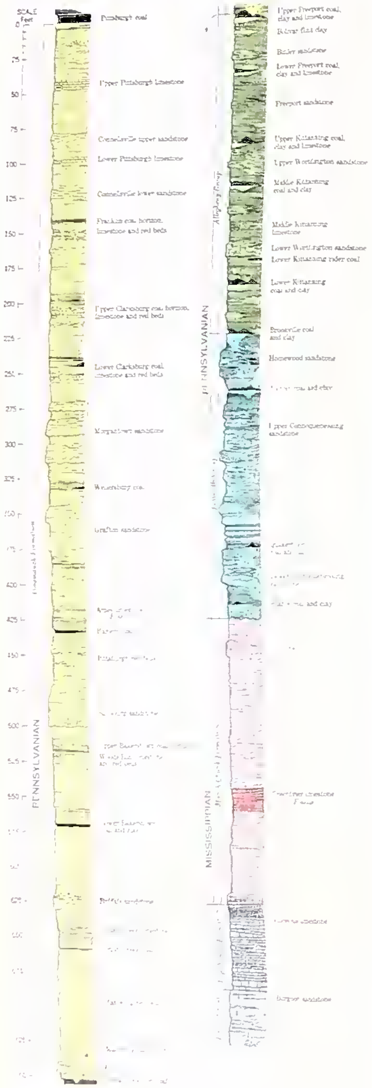
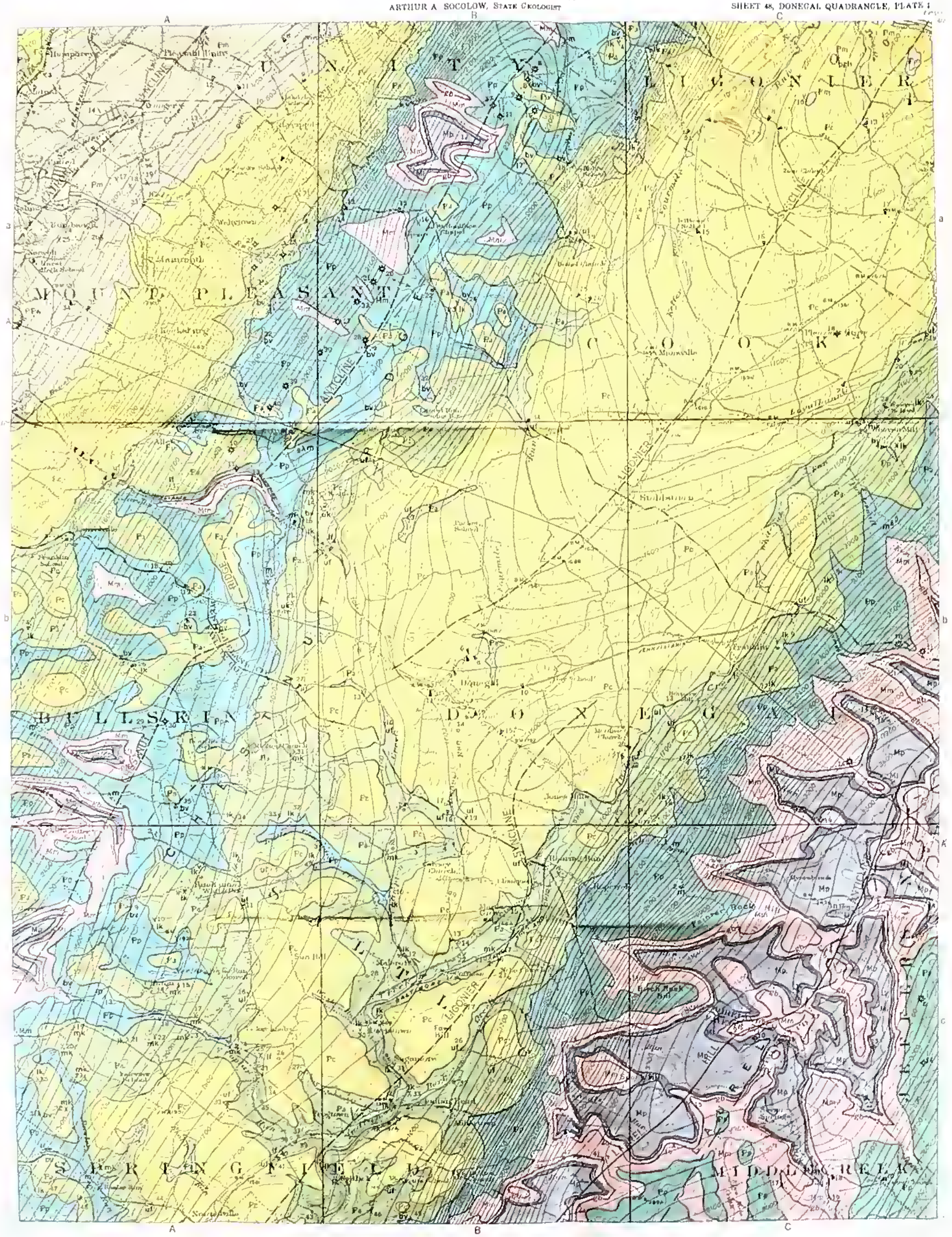
PLATE 1

PENNSYLVANIA DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, SECRETARY
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, STATE GEOLOGIST

Topographic and Geologic
ATLAS OF PENNSYLVANIA
SHEET 48, DONEGAL QUADRANGLE, PLATE 1

COMPOSITE STRATIGRAPHIC SECTION

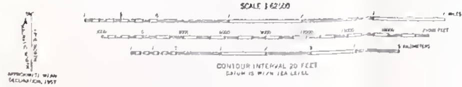

SCALE Feet
Pittsburgh coal
Upper Pittsburgh limestone
Connellsville upper sandstone
Lower Pittsburgh limestone
Connellsville lower sandstone
Upper Freeport coal, clay and limestone
Butler sandstone
Lower Freeport coal, clay and limestone
Freeport sandstone
Upper Kittanning coal, clay and limestone
Upper Worthington sandstone
Middle Kittanning coal and clay
Middle Kittanning limestone
Lower Worthington sandstone
Lower Kittanning rider coal
Lower Kittanning coal and clay
Brookville coal and clay
Homewood sandstone
Upper Connoquenessing sandstone
Morgantown sandstone
Grafton sandstone
PENNSYLVANIAN
MISSISSIPPIAN



Base from U. S. Geological Survey topographic map of the Donegal quadrangle, Pennsylvania. Surveyed in 1920. Revised in 1957.

Geology and mineral resources by M. E. Shaffner
1957 – 1961

GEOLOGIC MAP OF THE DONEGAL QUADRANGLE, PENNSYLVANIA



CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

1962

EXPLANATION

PENNSYLVANIAN AND PERMIAN

PPw
Washington Formation
Small remnant of lower part; shale

PENNSYLVANIAN

Pm
Monongahela Formation
Waynesburg coal at top, Pittsburgh coal at base; shale, sandstone, limestone, and coal beds

Pc
Conemaugh Formation
Top is base of Pittsburgh coal, base is top of Upper Freeport coal; shale, sandstone, limestone, and thin coal beds

Pa
Allegheny Group
Upper Freeport coal at top, Brookville (Clarion?) coal at base; shale, sandstone, limestone, clay, and minable coal beds

Pp
Pottsville Group
Massive sandstones, locally conglomeratic, with interbedded shale; clay and coal beds

MISSISSIPPIAN

Mm
gb
Mauch Chunk Formation
Red and green shale, thin sandstone, Greenbrier fossiliferous limestone (gb) in lower part

Ml
Mp
Pocono Group
Sandstone, some conglomerate, interbedded shale; Loyalhanna limestone Formation (Ml) at top

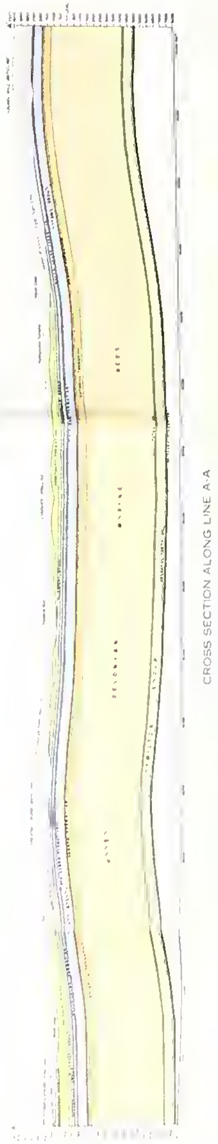
SYMBOLS

wbg	Waynesburg coal
pgh	Pittsburgh coal
uf	Upper Freeport coal
lf	Lower Freeport coal
uk	Upper Kittanning coal
mk	Middle Kittanning coal
lk	Lower Kittanning coal
bv	Brookville (Clarion?) coal
m	Mercer coal
⚒	Deep mine, strip mine, or quarry
▼	Outcrop
⁎	Core drill hole
✪	Gas well
☼	Gas show
✧	Dry hole

Structure contours on Upper Freeport coal bed. Contour interval 50 feet. Datum is mean sea level

Anticlinal axis

Synclinal axis



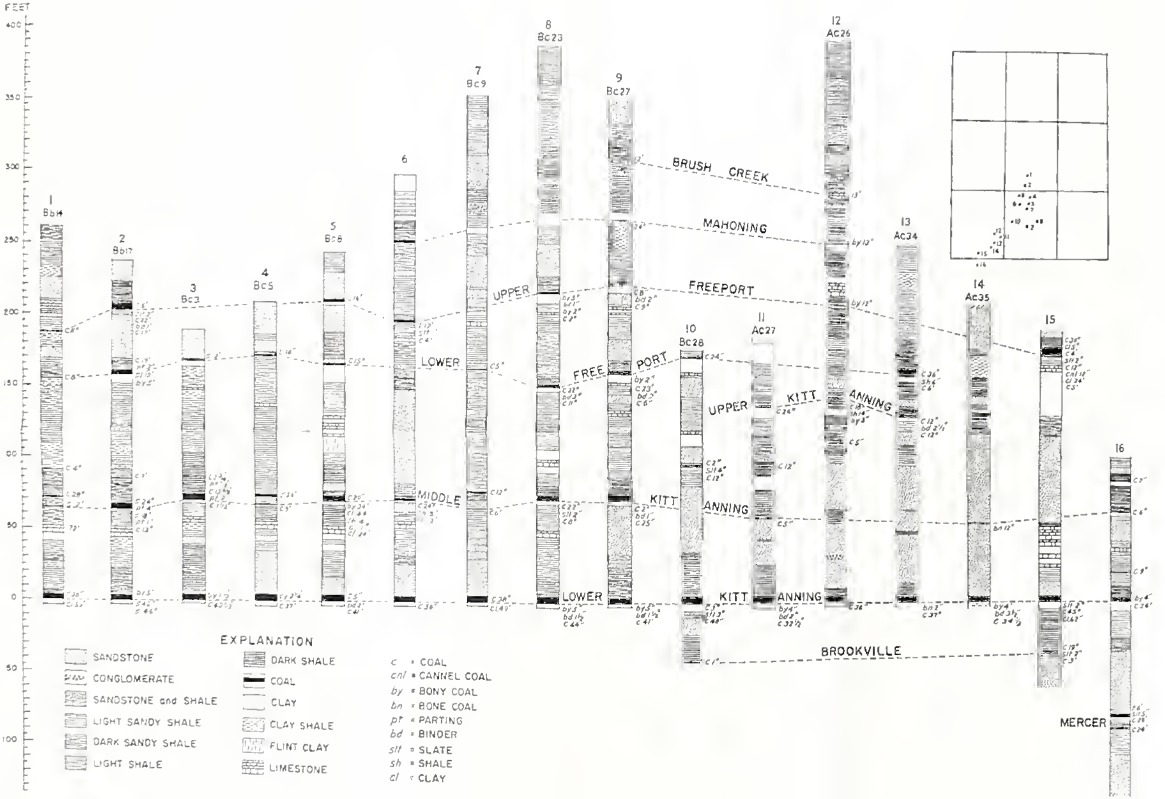
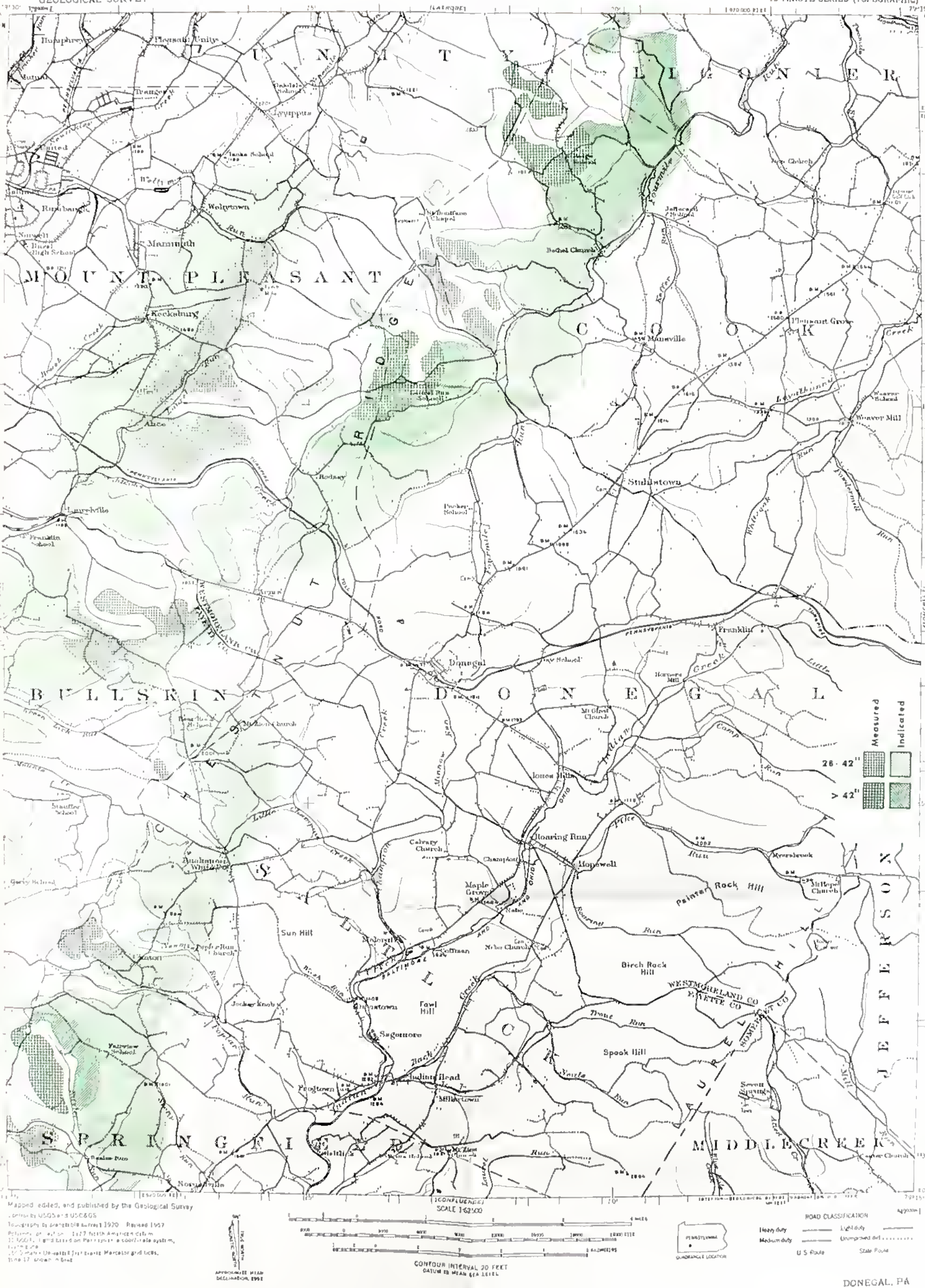


Plate 2. Core boring records from the Donegal quadrangle.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF PENNSYLVANIA
REPRESENTED BY THE
DEPARTMENT OF INTERNAL AFFAIRS
TOPOGRAPHIC AND GEOLOGIC SURVEY

DONEGAL QUADRANGLE
PENNSYLVANIA
15 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Topography by planetable surveys 1920. Revised 1957

DONEGAL, PA.
N4000—W7915/15
1957

Plate 3. Reserves of Brookville coal in the Donegal quadrangle.

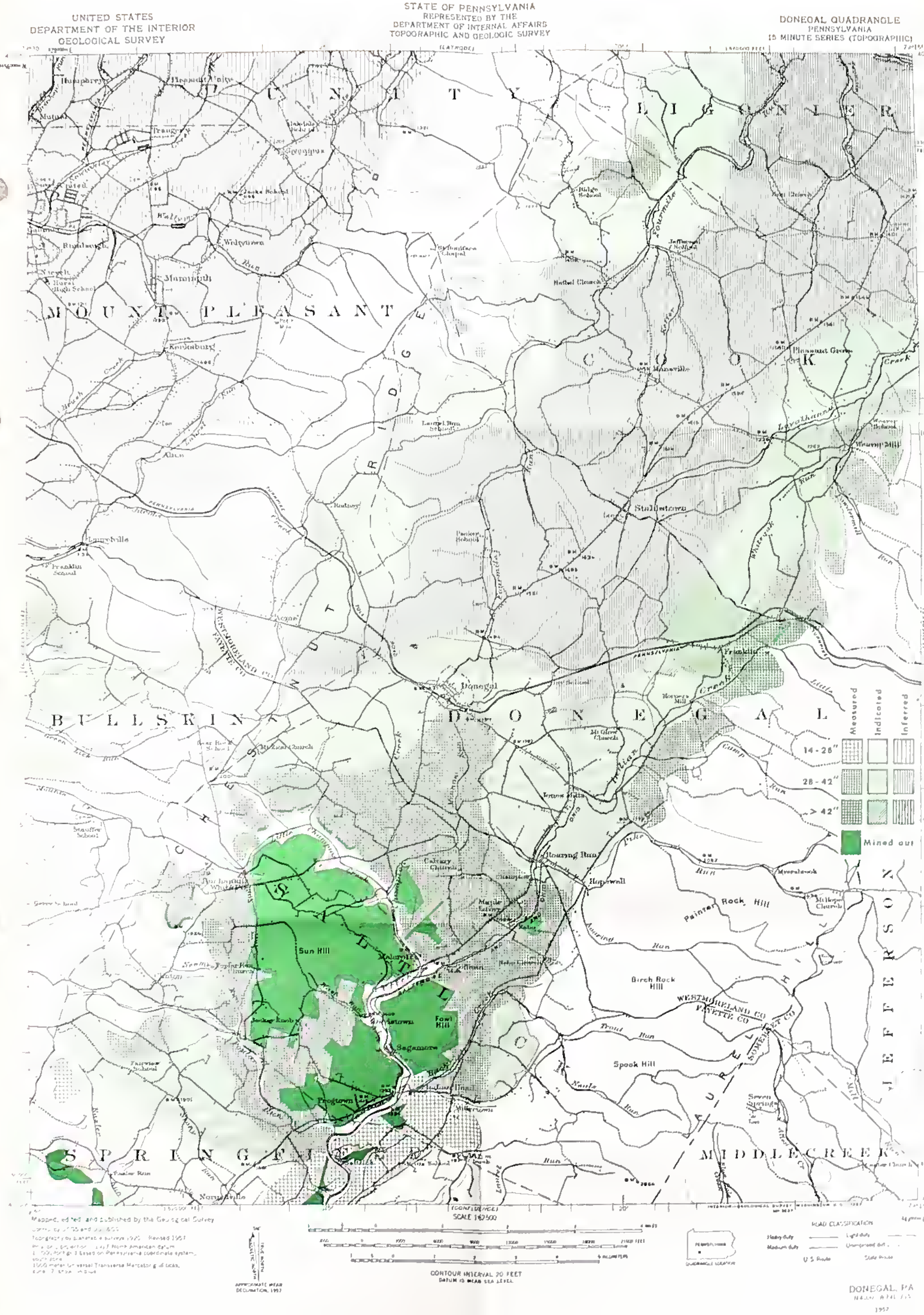


Plate 4. Reserves of lower Kittanning Coal in the Donegal quadrangle.